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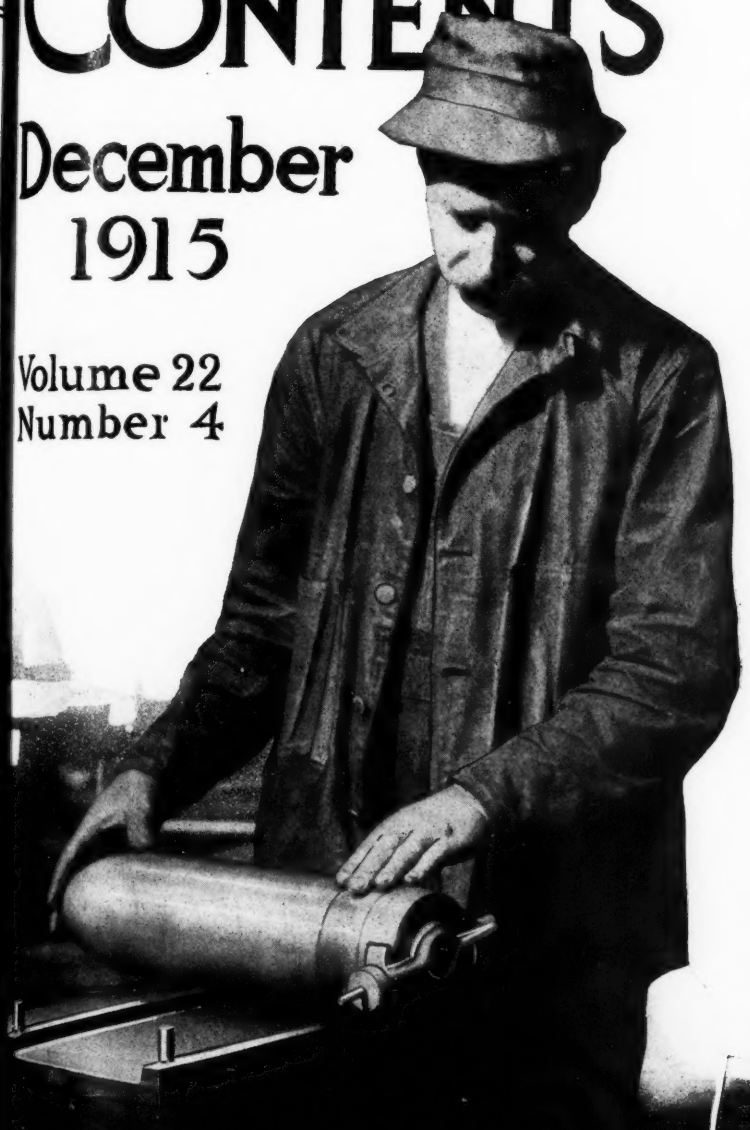

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Machine Tools Achieve Fame

Through the fearful instrumentality of a terrible war, the world has discovered that the machine tool industry, although relatively small in size and numbers employed, is an industry of such vital importance to a nation that government, civil and military, will hereafter need to have a definite knowledge of its character, extent and possibilities in order to realize the absolutely essential resources of a nation at war.

Behind guns and ammunition the world sees now, as never before, the men, machines and tools which must produce these implements and materials of modern warfare. They see the machinery manufacturer, the mechanical engineer, the machine designer and mechanic, not as mere commonplace figures in industry, but as factors of the utmost importance, to be mobilized like soldiers and war vessels, in military and naval plans and campaigns.

It is now realized by the people of every land, that great fortresses are of less importance to a nation than the capacity to produce guns and ammunition and to keep on producing them as rapidly as needed in the tremendous operations of modern warfare. The prosaic lathe, planer, drilling machine and other metal-working tools have taken on an importance rivaling the battleship and the submarine. The magnificent dreadnought, throbbing with life and terrible in its power of destruction, becomes a useless hulk, a helpless target, without the guns and ammunition produced in the machine shop.

It is well for the machine-tool industry that its importance in relation to warfare has been discovered, but of far greater significance is the fact that it will lead to a more general appreciation of the fundamental relation of this industry to the arts and industries of peace. And simultaneous with the discovery of what machine tools mean in war and in peace, will come the knowledge that in this country the industry has been brought to the highest point of development. In no country can be found in a single industry an aggregation of individuals manifesting so much mechanical ingenuity, manufacturing skill, technical knowledge and business enterprise. The High Explosive treatise in this number of MACHINERY is a convincing demonstration of high efficiency in American machine tools and machine-shop practice.

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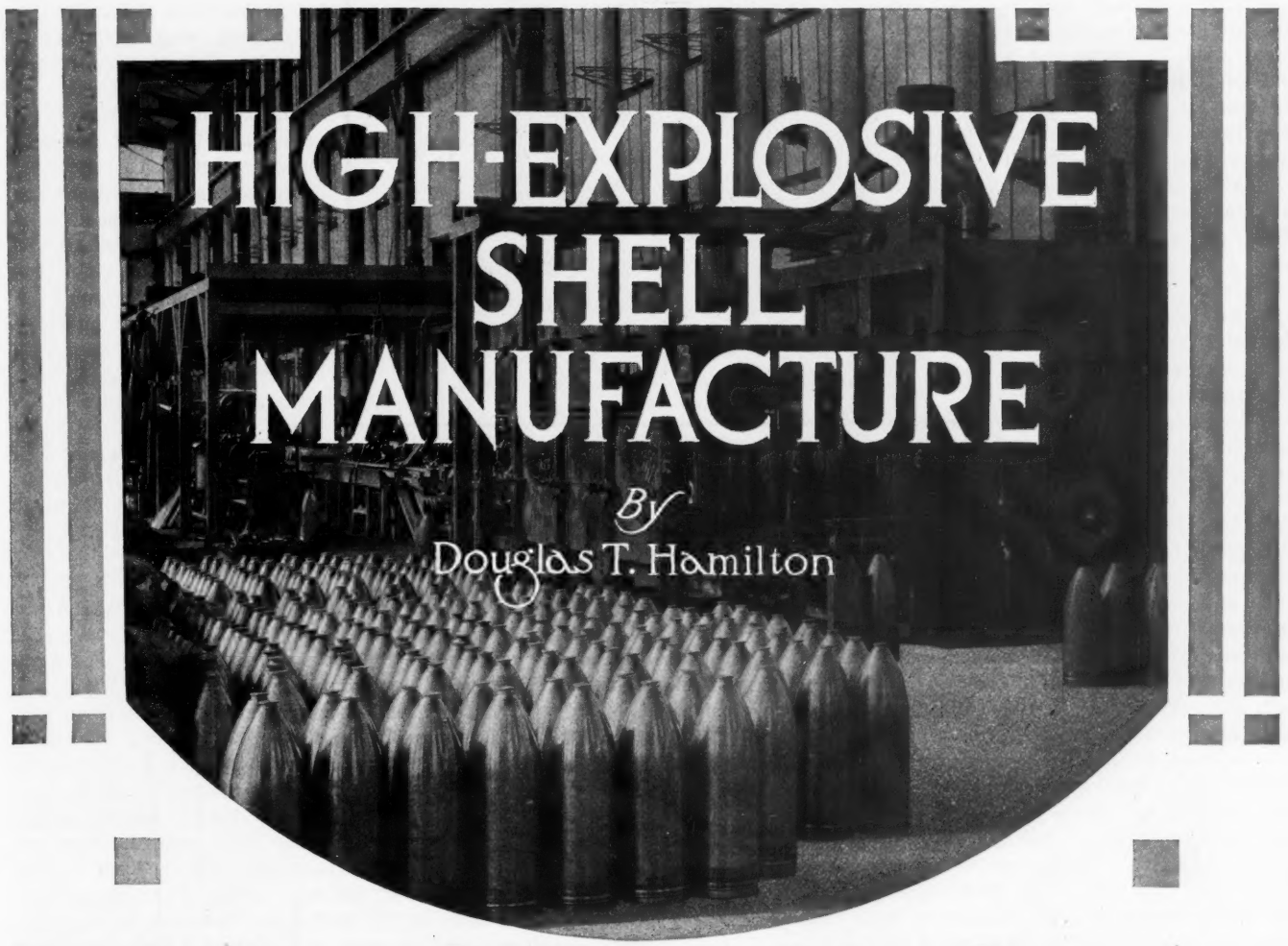


HIGH-EXPLOSIVE SHELL MANUFACTURE

By Douglas T. Hamilton

Production of Shells of the Common and Armor-piercing Types, Detonating Fuses, Cartridge Cases, Primers, Etc.

THE common high-explosive shell which is used chiefly for the destruction of fortifications did not come into general use until the latter part of the sixteenth century. About that time hollow balls of cast iron were filled partly with black gunpowder and partly with a slow-burning composition that was ignited by several different types of fuses. These shells did not give very satisfactory results. An improvement was later made that consisted in fitting into the shell a hollow forged iron or copper plug filled with slow-burning powder. The early shells were spherical in shape and were fired from smooth-bored guns (not rifled). They were used in this manner up to about 1871.

Development of High-explosive Shells

Upon the advent of the rifled gun, sabots, as shown in Fig. 1, were fastened to the base of the spherical shell and took the rifling grooves in the gun. These were usually made of wood and the rim was covered with sheet iron, steel or copper. When the first types of high-explosive shells burst, they broke into comparatively large pieces, and did not have a very destructive effect. Later developments consisted in making the shells from cast or forged steel and filling them with high-explosives such as lyddite, melenite, shimose, etc., instead of common black gunpowder. These shells were sometimes cast in sand molds head downward from steel of the proper composition to give the required strength. They were then annealed by leaving them in a furnace for a sufficient length of time to bring them to a red heat, after which they were removed and allowed to cool gradually in the air. The interior of the cast shell was seldom machined, except at the base end for the insertion of the base fuse, and the exterior was either ground or finished in a lathe and grooved at the base end to form a seat for the driving band.

Types of High-explosive Shells

There are four types of shells in use at the present time that may be said to be high-explosive. The first, but not the most common, is known as the high-explosive shrapnel shell. This type of projectile, shown at *A* in Fig. 2, combines the principles of both the high-explosive shell and the common shrapnel shell, and has been used by some governments within the past four or five years. In this shell the head or fuse carries a high-explosive charge and the matrix surrounding the bullets is a high-explosive material capable of being detonated by the detonation of the fuse. This projectile carries a combination time and percussion fuse and a base charge of black powder similar to the common shrapnel described in the April number of MACHINERY. For use as a common shrapnel, the fuse and bullets are expelled without any detonation,

the matrix serving to produce smoke as in the common shrapnel. The head or fuse continues in flight and detonates upon impact, causing considerable damage, and is capable of destroying the shield used in protecting a field gun. In the event that the fuse is set to explode upon impact, the high-explosive material in the head and the matrix in the shell detonate together, thus giving the effect of a high-explosive shell. The explosive commonly used in the head and as a matrix in this class of ammunition, is trinitrotoluol which is used in connection with fulminate of mercury, or other similar materials necessary to start the detonation. Fig. 4 shows the condition of one of these shells after being detonated upon impact, this shell not having filled the function of a common shrapnel shell. The projectile shown here is an American 3-inch caliber, high-explosive shrapnel weighing 15 pounds.

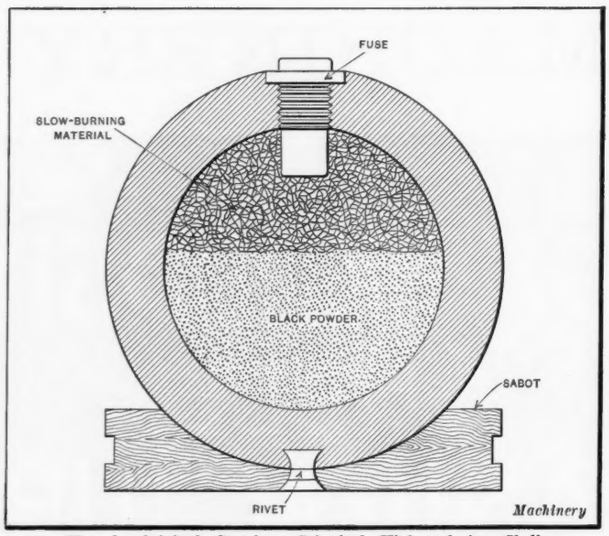


Fig. 1. Original Cast-iron Spherical High-explosive Shell

The shell shown at *B* in Fig. 2 is known as a common high-explosive shell, and is the type used in medium-caliber field guns by the Russian government. It will be noticed that the fuse or exploder is inserted in the nose end of the shell, and surrounding this there is usually a high-explosive, picric acid, lyddite or melenite, trinitrotoluol, etc. This shell is used principally against fortifications, although it can be used to some extent for field operations. It explodes upon impact and possesses enormous destructive power. Some idea of the great damage wrought by a modern high-explosive shell will be obtained by referring to Fig. 5, which shows the condition of an American 3-inch high-explosive shell after bursting. The fragments were obtained by exploding the shell in an enclosed sand pit.

The shell shown at *C* is used in coast defense and field guns and carries a fuse located in the base. When used by the American government in field guns, it is equipped with a delay-action fuse and carries from 3 per cent to 30 per cent of its weight of high-explosive. The lighter charged shells are used for repelling infantry attacks, whereas the heavier charged shells are used for destroying fortifications. One of these types is used as an armor-piercing shell; this contains a very large bursting charge and is furnished with a quick-acting fuse. It is used principally to repel attacks of light armored vessels or for attacking the upper works of heavily armored ships. It accomplishes its purpose by exploding upon impact, driving in the thin plates and destroying those parts not protected by heavy armor.

The type of shell shown at *D* in Fig. 2 is also known as an armor-piercing shell. This carries a much lighter explosive charge than the shell shown at *C*, and is made with much thicker walls. This shell carries a delay-action fuse, which permits the projectile to pass through the armor plate and into the interior of the vessel before exploding.

Construction of Modern High-explosive Shells

High-explosive shells are made at present in a variety of shapes and sizes, ranging all the way from 1.4 inch to 16 inches in diameter and from 1 to 2400 pounds in weight. The high-explosive shells used by various governments also differ considerably in construction. For instance, the American government uses a solid-point nose shell shown at *A* in Fig. 3. This shell is almost the same in construction as the armor-piercing shell, and can be used, of course, against light armored cruisers or the upper works of heavily armored ships. The shell is provided with a rifling band near the base and also with an inserted bronze plug in which the base type of fuse is held. The type of fuse used varies in accordance with the use to be made of the shell. For instance, in mountain guns, howitzers, and mortars, a centrifugal type of fuse as shown in the illustration is generally used, whereas for high-velocity field guns a ring-resistance fuse as will be described later is generally employed. The cartridge case and primer held in the base are similar in construction to those used on shrapnel shells. This type of high-explosive shell explodes upon impact only and the cavity is filled with an explosive

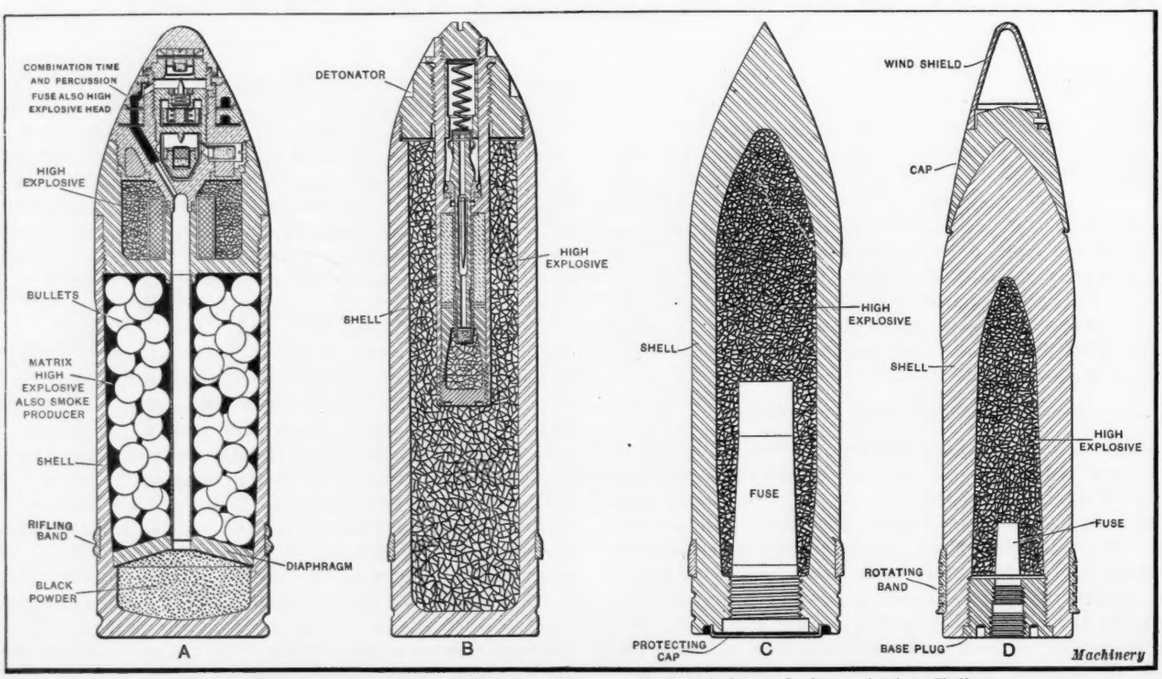


Fig. 2. Diagrammatical Views of Different Types of High-explosive and Armor-piercing Shells

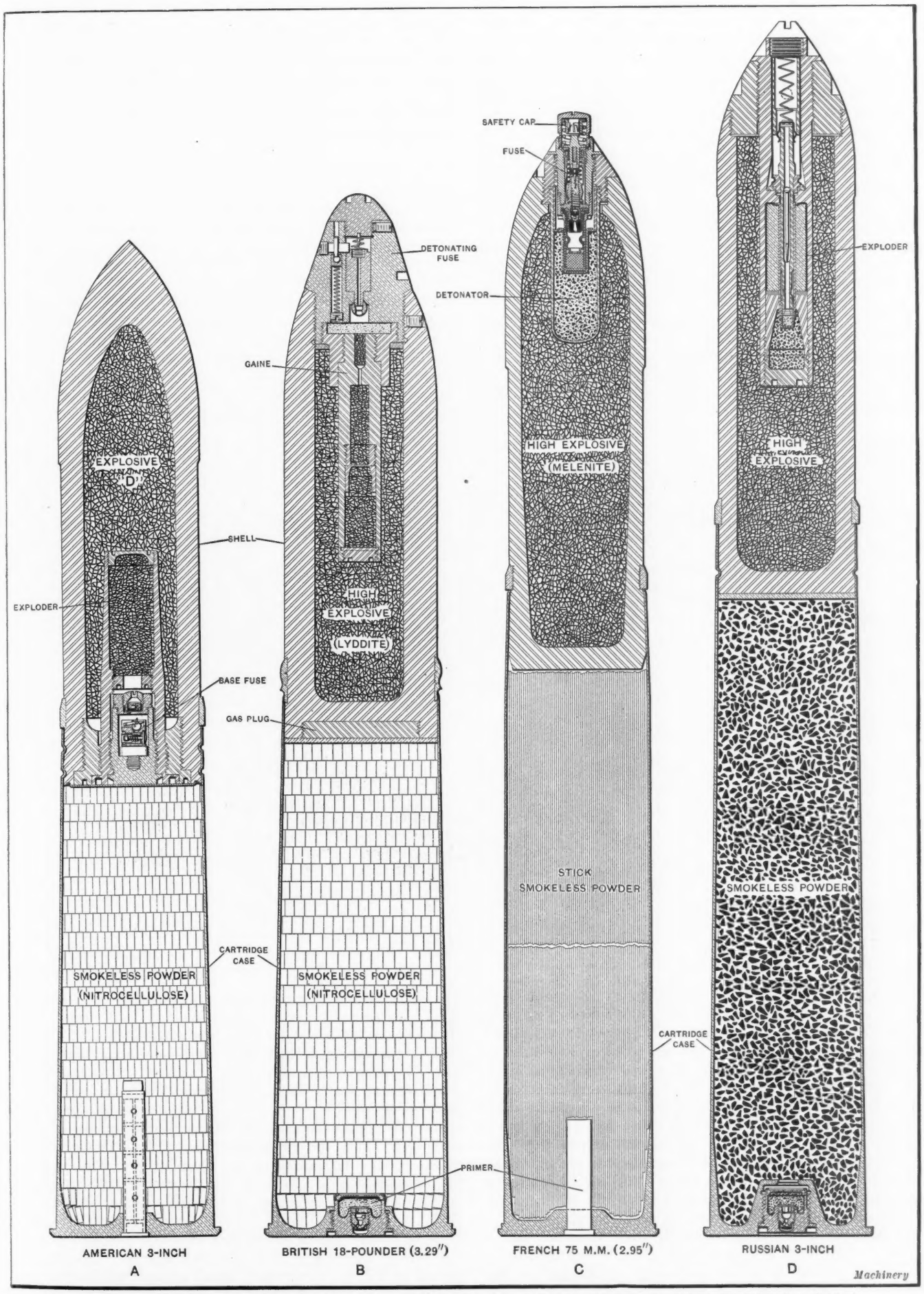


Fig. 3. Types of High-explosive Shells used by American, British, French and Russian Governments (About One-third Actual Size)

called explosive "D" from its inventor Lieut.-Col. B. W. Dunn. This is also sometimes known as "dunnite." Dunnite is not a sensitive explosive and consequently it requires considerable shattering effect to detonate it. In order to accomplish this, quite a heavy detonating charge is used. The detonating composition is made of picric acid in various portions or T. N. T. (trinitrotoluol).

The British 18-pound high-explosive shell is shown at *B* in Fig. 3. This shell, it will be noticed, is provided with very thick walls and carries a charge of high-explosive, gen-

erally lyddite. A nose fuse instead of a base fuse is used and the fuse operates on percussion only as will be described later. In order that the lyddite be satisfactorily detonated, the fuse has an extension known as a gaine which continues down into the cavity of the shell for quite a distance. This gaine is filled with three different detonating materials, each successive one being more powerful than the last. In other words, this shell is set off by what is known as the delay-action fuse. This allows the shell to penetrate fortifications or earthworks before it is detonated, and consequently enables the explosion to have a much more destructive effect than if it took place instantaneously upon impact. This particular size of high-explosive shell is generally made from bar stock and in order to avoid chances of piping, a gas plug is inserted in the base of the shell as shown. The cartridge case and primer held in the base are the same as those used on the shrapnel shell.

The now famous French 75-millimeter high-explosive shell is shown at *C* in Fig. 3. This shell is made from a forging having comparatively thin walls, and it is hardened and heat-treated to increase its elastic limit and tensile strength. It also carries a delay-action fuse in the nose that is of interesting construction, as will be described later. The cavity in the shell is generally filled with a high-explosive known as melenite, the base of which is picric acid. The melenite which is used in the cavity of the shell itself is poured in while in a liquid form and solidifies upon cooling. The exploder, shown extending from the end of the fuse into the explosive, is filled with melenite in powder form. The characteristics of the detonator and bursting charge have to be similar in order that the greatest possible shattering effect may be produced. The fuse used in this shell is also of the delay-action type and enables the projectile to penetrate earthworks or fortifications before detonation takes place. The cartridge case is similar to that used on the shrapnel shell and is filled with smokeless powder (nitrocellulose) in stick form.

The Russian 3-inch high-explosive shell is shown at *D* in Fig. 3. The shell proper is made from a forging that is heat-treated before or after machining, depending on the practice followed. This must have an elastic limit of not less than 62,000 pounds per square inch and a tensile strength of 118,000 pounds per square inch. This shell also carries a detonating fuse in its nose, and upon reference to the illustration it will be noted that it differs considerably from any of the fuses previously illustrated. This fuse is not of the delay type, but is practically instantaneous and detonates the high-explosive material in the shell upon impact. The cartridge case carries a heavy charge of smokeless powder—generally nitro-cellulose—and also a primer in the base end somewhat similar in construction to that used in the British shell. This projectile has a muzzle velocity of over 1900 feet per second, and as the shell proper is heat-treated it has considerable destructive effect when the high-explosive contained within it is detonated.

Armor-piercing Projectiles

Following the introduction of iron sheathing for ships, it was found that the ordinary cast-iron high-explosive projectile did not readily pierce the plate, so that it became necessary to produce a projectile which would pierce the armor. This was accomplished by Sir W. Palliser, who invented a method of hardening the head of the pointed cast-iron shell. This was done by casting the projectile point downward and forming the head in an iron mold; the metal at the point being suddenly chilled became intensely hard, while the rest of the casting remained comparatively soft. The casting when partially cold was taken out of the mold and thrown down in the sand, where it was allowed to cool off gradually. These shells proved very effective against wrought-iron armor, but had little effect against steel armor plates. An improved shell was then devised which was made from forged steel with a point hardened so as to pierce the armor. This projectile is generally formed from steel containing both nickel and chromium, and sometimes tungsten. Armor-piercing shells are generally cast from a special mixture of chrome-nickel steel, melted in a crucible and afterward forged into shape. The shell is then thoroughly annealed, bored internally and turned on the exterior in a lathe. The heat-treatment consists in hardening the head of the projectile and tempering it in such a manner that the rear portion is reduced in hardness so as to render it extremely tough, whereas the point is extremely hard. There are two types of armor-piercing shells; one is known as a shot and is used for piercing armor, carrying a light bursting charge. The other is known as a shell; it carries a much heavier bursting charge, is longer, has thinner walls, and is much more destructive.

As shown at *D* in Fig. 2, the armor-piercing shell is similar in shape to the common high-explosive shell shown at *C*, with the one exception that the walls are much thicker and the point of a still greater thickness. In order to greatly reduce the air resistance encountered in flight, armor-piercing shells are provided with a long pointed outer covering

Fig. 4. Condition of an American 3-inch High-explosive Shrapnel after being exploded upon Impact (Annual Report, Smithsonian Institution, 1914)

for the head. It was also found that if an armor-piercing shell having a hardened nose struck an armor plate with great force, the force of the blow shattered the head and made it ineffective. A soft steel cap was then placed on the shell; this gave the point support and greatly improved the chances of the projectile getting through a hard armor plate unbroken. One of the plausible theories advanced as to the ineffectiveness of an uncapped head is as follows: When an uncapped projectile strikes the extremely hard face of a modern armor plate, the whole energy of the projectile is applied at the point, and the high resistance of the face of the plate puts the very small arc at the point of the projectile to a stress greater than the metal can resist. The point is therefore broken or crushed and the head of the projectile is flattened. This greatly reduces the penetrating power and results in the point of the projectile being practically welded to the armor plate. When a capped projectile strikes a hard plate, the resistance of the plate is distributed over a greater area, and, in addition, the point is supported by the soft metal cap. Consequently, the point is not deformed and passes through the plate.

The specifications for the test governing the manufacture of armor-piercing projectiles are very stringent and require that the shell perforate a hard-face armor plate as thick as the caliber of the projectile without breaking the point. In other words, a 6-inch projectile is required to completely perforate a 6-inch armor plate and pass through it in an unbroken condition.

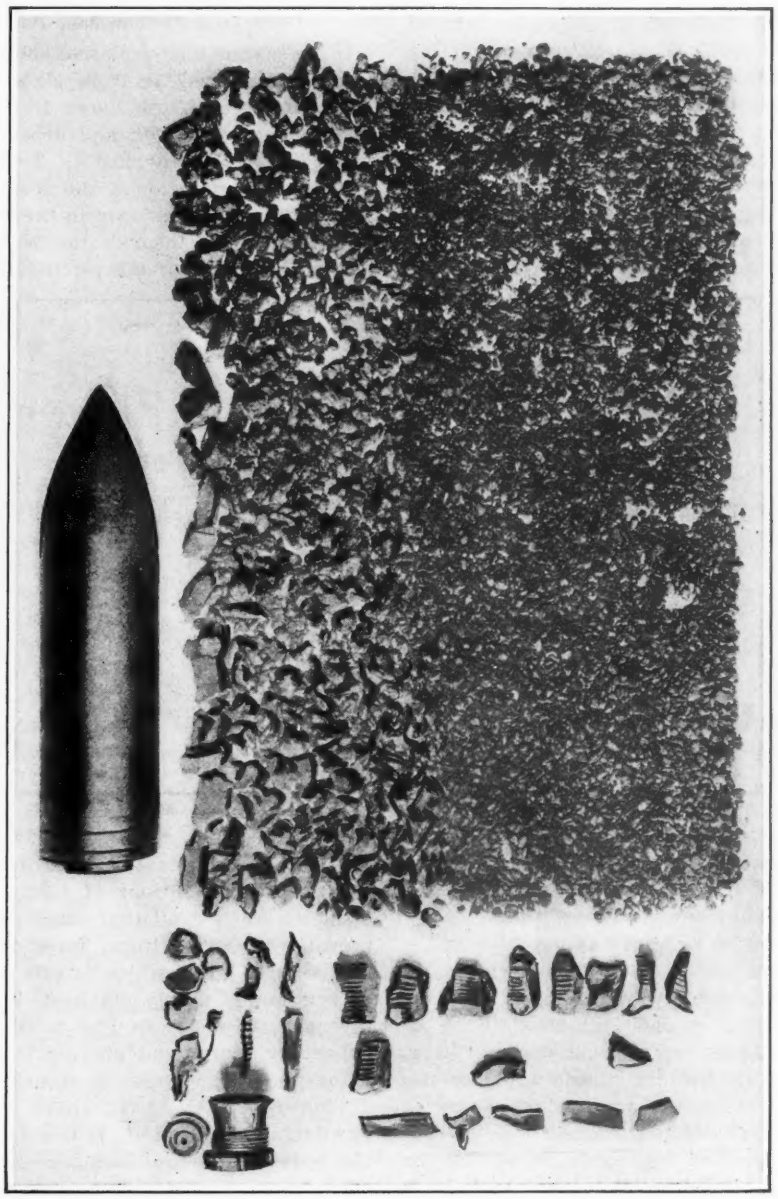


Fig. 5. Condition of a 3-inch American Common High-explosive Shell after passing through a Steel Plate and into a Bank of Sand, and after bursting (Annual Report Smithsonian Institution, 1914)

General Methods of Manufacturing High-explosive Shells

At present there are two general methods of manufacturing high-explosive shells. One is to make the shell from bar stock, removing the excess material to form the cavity by means of high-power drilling machines, whereas the other is to forge the shell to approximately the correct shape. Until within the last few years, cast-iron shells were used quite extensively; these were cast in sand molds using a core to form the cavity. Great difficulty, however, was experienced in obtaining a casting free from flaws and other imperfections, and this method has generally been superseded by either the forged or bar stock shell. When the shell is made from bar stock, it is usually found necessary to fit a gas plug in the base end to eliminate any chances of piping. At present, cast-iron shells are still used for target practice.

High-explosive shells are made in three distinct types as has been already mentioned. They are those with a solid base carrying a nose fuse, those with a solid nose carrying a base fuse, and those with an open nose and base carrying a nose fuse. If the shell is intended to carry a nose fuse, the base end is shaped in forging by the press and the nose subsequently formed to shape by a nosing-in die. In small shells of about 2 inches diameter, the nose when red-hot can be spun over in the lathe by properly formed tools. However, it is usually closed in by a press. For base fuse shells, the nose is produced by the forging machine and the base is subsequently formed by pressing the metal to the required shape.

Generally speaking, the operations on a British high-explosive shell when made from forgings are as follows: Bar stock of the required diameter is first cut off into billet lengths, then these billets are heated to about 1900 degrees F., and by subsequent piercing and drawing operations are drawn out to the correct length and diameter. Following this, the mouth end and base end are trimmed and faced off. Then several operations are performed on the external diameter of the shell, such as turning, grooving, etc. The shell is then held in a chuck and several operations are performed on the cavity, after which it is nosed-in, the final operations consisting in machining the nose, pressing on the band, machining it, testing, etc. After the shell has been completely machined, it is filled with lyddite. In filling the shell, great precautions are taken to prevent the melted lyddite (which contains picric acid) from coming in contact with certain materials, such as combinations of lead and soda, which produce sensitive picrates. The shells are consequently painted externally with a special non-lead paint and lacquered internally with a special lacquer. The picric acid is then melted in a pot, the temperature being carefully controlled. Then certain ingredients are added to reduce the melting temperature of the picric acid. The melted material is then poured into the shell through a bronze funnel, the latter forming a space for the exploder. In cooling, the material solidifies into a dense hard mass.

The French high-explosive shell was adopted in 1886. The high-explosive used in this shell was melenite and it was originally put into an ordinary cast-iron common shell having thick walls. Afterward a forged steel thin-walled shell was introduced, as shown at *C* in Fig. 3. The general manufacturing methods on this shell are first cutting off a billet of the required length, heating and forging. The French shell is made with thin walls and consequently is hardened and heat-treated in order to give it the correct tensile strength. The operations on the French shell differ from those on the British shell in that no machining is done on the inside of

the shell or the cavity. Usually after forging, the forgings are pickled. Then the base end is faced and centered, the external diameter is turned, after which the shell is nosed-in. Following the nosing-in operation, the shell is hardened and tempered, after which it is faced off on the nose end, bored, reamed, threaded and finally ground or turned on the external diameter; after this the rifling groove is cut, the rifling band pressed in and turned to shape. In order to avoid the formation of picrates, the interior of the shell is lacquered, and the external surface painted with a non-acid paint. The melenite is then melted and poured in.

HIGH-EXPLOSIVE SHELL FUSES

Various types and forms of fuses or detonators are used in high-explosive shells, some governments using a plain type of concussion fuse held in the base end of the shell, and to which no gaine is attached. This fuse, of course, is set off upon the impact of the shell against fortifications or other obstructions. Others use percussion fuses of extremely complicated design which are provided with exploders that extend down into the cavity in the shell. These carry a detonating primer and exploding material for detonating the high-explosive contained in the cavity of the shell. Where ordinary black powder is used to burst the shell a high-power detonator is not necessary. The direct-action or impact fuses, of course, are more simple in construction than the combination time and percussion fuses, and they are usually made of material that will withstand considerable pressure without crushing.

High-explosive shell fuses may be divided into two distinct groups: First those that explode instantaneously upon impact, and second, those that explode shortly after impact, or in other words, those in which the detonating action is slightly delayed. From the standpoint of design and operation these groups are subject to a still further division. For example, some fuses are started or "unloaded" by the gas pressure in the gun, others upon rotation, and some a combination of both. Then there are the types employing split rings, centrifugal bolts, springs, etc., or a combination of two or more different actions.

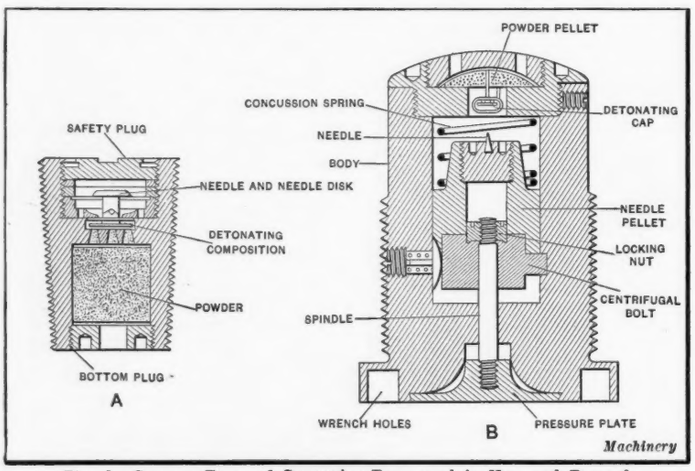


Fig. 6. Common Types of Concussion Fuses used in Nose and Base of High-explosive Shells

Common Type of Concussion Fuse

A common type of concussion or direct-action fuse which fits in the nose of the shell and is set off upon impact is shown at *A* in Fig. 6. The fuse body and other important members are made from steel of sufficient strength to be discharged from the gun without rupture, but upon striking, the needle disk is crushed in and the needle explodes the detonator which, in turn, explodes the powder in the base of the fuse. At *B* in Fig. 6 is shown the common type of concussion fuse used in the base of high-explosive shells. In this fuse, before firing, the needle pellet is held back by a central spindle which has a pressure plate attached to its rear end. A centrifugal bolt is also inserted for additional safety, which is released by the rotation of the shell. In action, this fuse works as follows: Upon the discharge of the projectile from the gun, the gas pressure pushes in the pressure plate so that the central spindle is carried forward, unlocking the centrifugal bolt. The needle pellet is then free to move forward and explode the detonating cap when the shell strikes. These two types of fuses are not very extensively used at the present time, and have been superseded in general by more complicated but effective fuses.

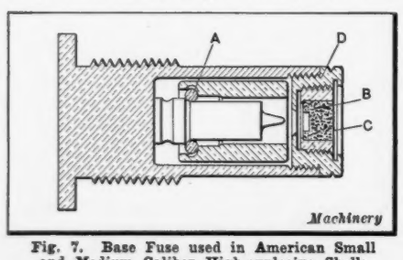


Fig. 7. Base Fuse used in American Small and Medium Caliber High-explosive Shells

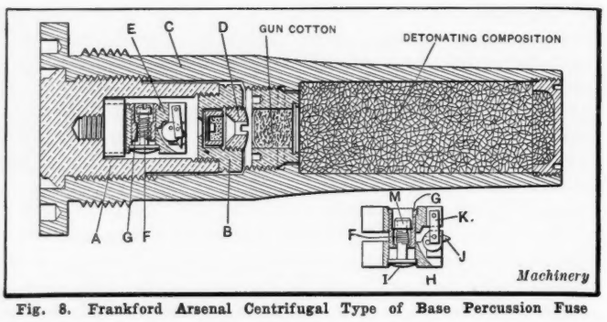


Fig. 8. Frankford Arsenal Centrifugal Type of Base Percussion Fuse

American Base Percussion Fuse

In American high-explosive shells fired from one- and two-pounders, as well as from six-pounders and 2.38-inch field guns, the type of fuse shown in Fig. 7 is used. This fuse is of simple construction and depends for its action upon the expanding of a split ring *A*. As the primer end of the fuse is toward the interior of the shell the flame passes from the priming charge *B* directly to the bursting charge in the shell without passing through the body of the fuse itself. The primer cup contains the percussion composition and priming charge, and is enclosed at its outer end by means of a brass disk *C* secured in place by crimping over the outer end of the primer holder, or brass closing screw *D*. The act of arming this fuse is simple, and as previously explained, depends upon the expanding of the split ring, which is accomplished when the shell strikes a solid body.

Centrifugal Type of Base Percussion Fuse

In the case of ring-resistance fuses, or in fact, in any fuse the action of which depends upon the longitudinal stresses developed by the pressure in the gun, the conditions of safety in handling and certainty of action are not all that could be desired. A fuse which is armed by the centrifugal force developed by the rotation of the projectile, and which is safe until the maximum velocity of rotation is nearly obtained, is secured in the Frankford arsenal fuse shown in Fig. 8, where a separate view of the expanding centrifugal plunger is also shown, presenting the firing pin in the armed position.

This fuse is used in shells fired from mountain guns, howitzers and mortars. It is made up of two principal parts, the body *A* and the closing screw *B*, which are held in the steel stock *C;* this also carries the detonating charge. The primer or detonating agent is also held in the nose of the fuse, and to reach the exploder the flame passes through a small vent in the primer closing screw *D* to the guncotton, which facilitates and increases the igniting effect. The centrifugal plunger, shown in the armed position at *H*, is made in two parts, which when the fuse is at rest are held together by the pressure of a spiral spring *F* contained in the cylindrical bushing *G* secured to each end of the plunger halves. The spring exerts its pressure on half of the plunger through the bolt *I*. Pivoted in a recess in one half of the plunger is the firing pin *J*, which, when the fuse is at rest is held with its point below the front surface of the plunger by the lever action of the link *K* that is pivoted to the other half. When subjected to the action of centrifugal force developed by the

rapid rotation of the projectile in passing from the bore of the gun, the two halves of the plunger separate. This separating movement causes the rotation of the firing pin *J*, the point of which is now held in advance of the front surface of the plunger, to pierce the brass primer shield and ignite the detonating composition. When the fuse is armed the end of the link *K* rests on the pivot of the firing pin, thus affording support to the firing pin when it strikes the percussion primer. The amount of separation of the plunger parts is limited by the nut *M* coming to a bearing on a shoulder in the bushing *G*, and thus preventing the diameter of the expanding plunger from equalling the full diameter of the hole in the fuse body. A stud screwed into the head of the fuse stock engages a corresponding slot cut through the bottom of both plunger halves and insures the rotation of the plunger with the shell. The strength of the spring *F* is adjusted so that the fuse will not arm until its rapidity of rotation is a certain percentage of that exerted in the shell in which it is used, and so that it will surely arm whenever the rapidity of revolution approximates the speed of rotation of the shell when fired. In the case of the parts of the plunger being accidentally separated and the fuse armed by a sudden jolt or jar in transportation or handling, the reaction of this spring will immediately bring the plunger back to its unarmed position.

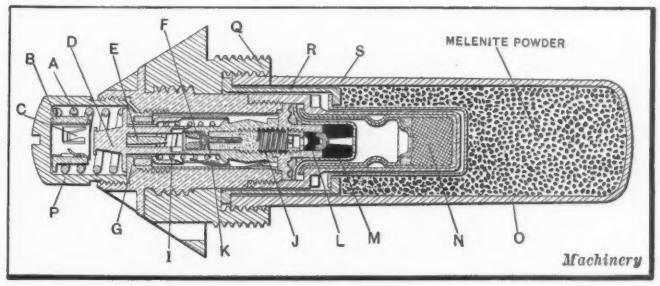


Fig. 11. French Detonating Fuse for Use in 75-millimeter High-explosive Shells

British High-explosive Fuse

The fuse shown in Fig. 9 is known as the British 100-graze high-explosive fuse, and it is used in British high-explosive shells that are fired from field and mountain guns. This fuse explodes upon impact only and screws into the nose of the shell. All of the parts of this fuse except the adapter and gaine are made from brass or bronze. It operates as follows: When the shell is fired, and before it commences its rotary motion imparted by the rifling in the gun bore, the impact of the explosive charge in the case causes the combined top and bottom detent *A* and *B* respectively, to drop back and compress the detent spring *C*. The detent assembly, as will be seen, is made in two pieces, and as the stem *A* is free to move out of alignment it drops to one side, by the action of gravity, when it is forced back; thus it is caught by the edge of the counterbored hole and prevented from taking its original position.

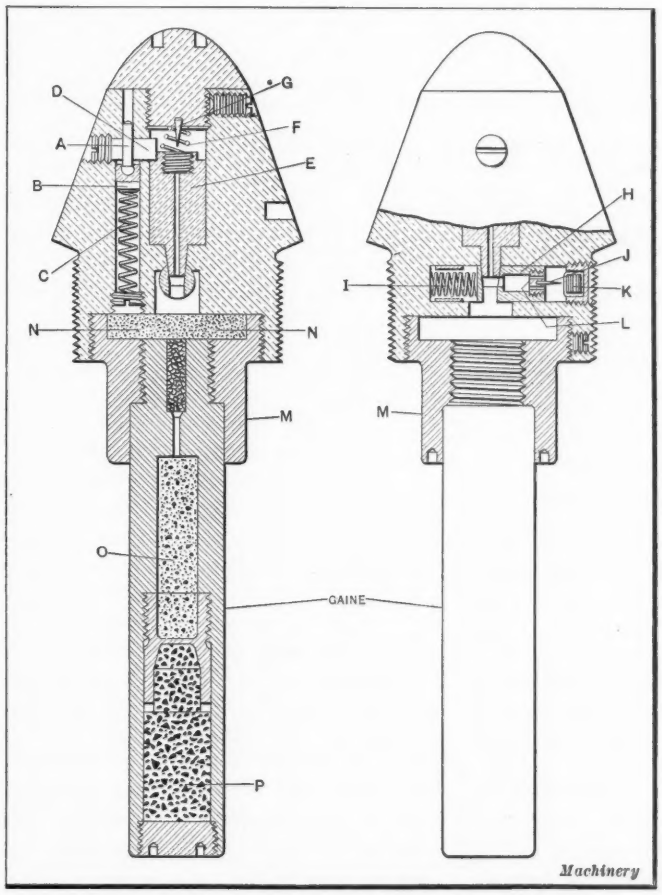


Fig. 9. British No. 100 Graze High-explosive Shell Fuse

By this time the centrifugal action of the shell throws centrifugal bolt *D*, whose path is now clear, out of the way of the graze pellet *E*. The only member that now prevents detonation is the hair spring *F*. The slightest impact causes the relatively heavy graze pellet to jump forward and explode the shell. The primer that is held in the counterbored end of the graze pellet is exploded upon impact with needle *G*, and from here the flame extends down into the other explosives in the gaine as will be described later. The primer in pellet *E* is loaded with a composition composed of 45 parts chlorate of potassium, 23 parts sulphide of antimony and 32 parts fulminate of mercury. The different constituents are measured by weight, and are loaded into the primer cup under a pressure of 600 pounds, after which the cup carrying the explosive charge is dried.

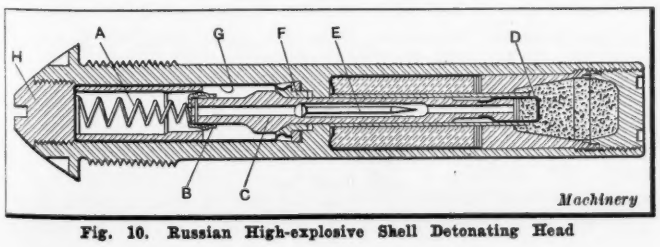


Fig. 10. Russian High-explosive Shell Detonating Head

Should the primer in pellet *E*, for any reason, fail to explode, there is a second detonation that takes place simultaneously. As will be seen in the view to the right, the lower end of pellet *E* is tapered and is seated in a cross hole in the percussion pellet *H*. When the graze pellet moves forward, pellet *H* is released and the centrifugal action combined with spring *I* drives the pellet carrying needle *J* against primer *K*, exploding it. The flame passes through four small holes in the needle holder *L*, thence into the chamber and from there down into the gaine containing the detonating charges.

The gaine is held to the fuse body by adapter *M*. It is provided with three chambers *N*, *O* and *P*, which contain different high-explosives, each succeeding one being of greater power than the last. Chamber *P* is filled with lyddite in flake form. The flame from the detonating primers first explodes the material in chamber *N*, then that in chamber *O* and then that in chamber *P*, which causes such a terrific shattering effect that the lyddite in the shell is detonated and blows the shell to atoms—some parts to the fineness of sand. It is stated upon good authority that after a shell has been detonated it is impossible to find the gaine or its parts, so terrific is the effect of the explosion.

Russian High-explosive Fuse

The Russian high-explosive fuse or detonating head used in high-explosive shells is shown in Fig. 10. This detonating head explodes upon impact, and the gaine is a part of the head, extending down into the explosive material in the cavity of the shell. It operates in the following manner: The force of impact of the shell against a solid body overcomes the resistance of spring *A* and stirrup *B*, allowing striker rod *C* to move forward into the cavity occupied by spring *A*. Attached to the lower end of striker rod *C* is a detonator pellet *D*. This carries a charge of mercury fulminate and in coming in contact with the steel needle *E* is exploded. The flame passes from this detonator down into the detonating composition held in the base of the fuse and ignites it, thus exploding the high-explosive material held

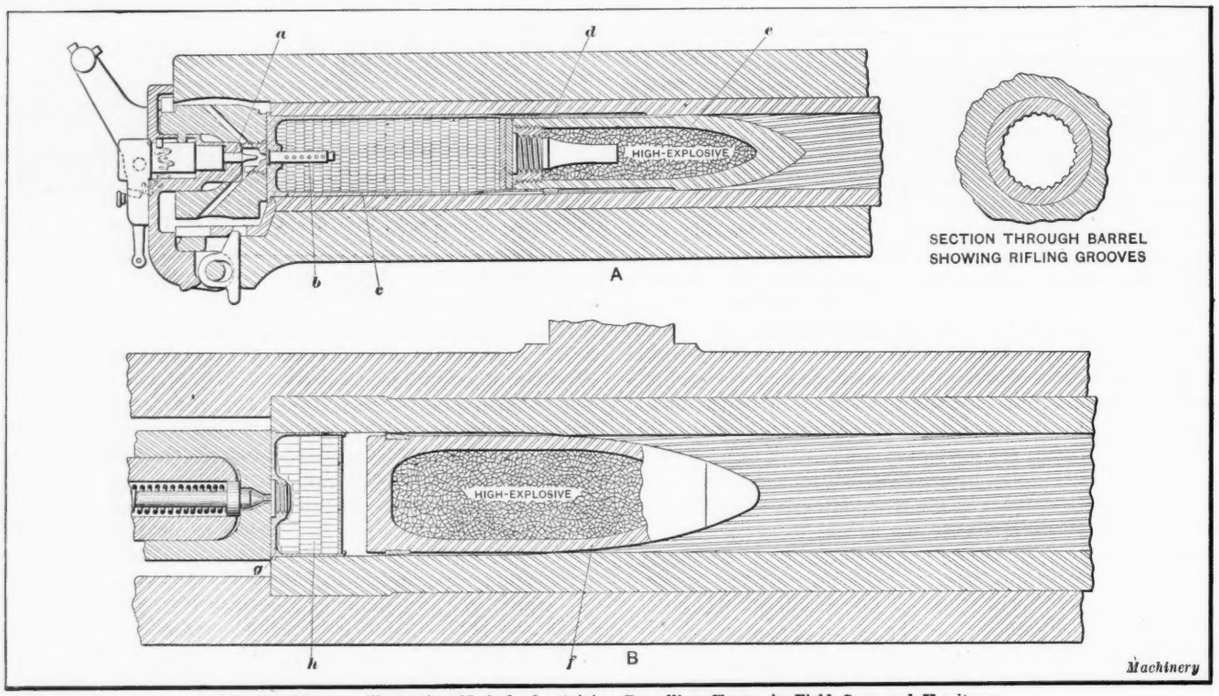


Fig. 12. Diagram illustrating Method of retaining Propelling Charge in Field Guns and Howitzers

in the cavity of the shell. Needle *E* is held in a steel plug *F* and the latter is kept from moving up with striker rod *C* by means of a striker casing *G* which is crimped around it as shown and extends up through the body of the fuse, coming in contact with the lower face of the head plug *H*. In order that the body of this detonator be capable of resisting considerable shock, it is made from high tensile strength steel, generally alloy steel, of about 110,000 pounds per square inch tensile strength.

French High-explosive Fuse

A high-explosive shell fuse of the delay-action type used in the French 75-millimeter high-explosive shell is shown in Fig. 11. This is provided with a safety head and is carried in the nose of the shell. In action, this fuse works as follows: Upon the discharge of the projectile from the bore of the gun the gas pressure overcomes the resistance of spring *A*. This causes bushing *B* to drop back, and stirrup *C*, which is held to it as shown, grips the head of plunger *D*. Plunger *D*, it will be noticed, completely envelopes firing pin *E* and prevents the detonator *F* from being accidentally discharged. When this plunger is withdrawn it exposes the firing pin *E*, which is riveted to the retainer *G*, and does not move with the plunger.

The fuse is now in the armed position, and as soon as it strikes a solid body the resistance of springs *I* and *J* is overcome and primer *F* is thus free to contact with firing pin *E*. The flame from primer *F* ignites guncotton *K*, and the powder surrounding it. This ignites the compressed gunpowder in cups *L* and *M*, which results in quite a powerful explosion and explodes the detonating composition in cup *N*. This, in turn, explodes the detonator *O* which is filled with melenite in flake form. It will be seen from this that the fuse does not detonate the high-explosive composition in the shell instantaneously, but causes a series of explosions, finally resulting in the detonation of the melenite in the shell by the exploder which extends into it. All the working parts of this fuse are made from brass or bronze with the exception of safety cap *P*, nose *Q*, cup *R* and exploder cup *S*; these are made from steel.

LOADING PROPELLING CHARGES IN GUNS AND HOWITZERS

In the early cannon the spherical shot and powder charges were rammed in from the muzzle of the gun the same as in loading small arms. It was not until early in the eighteenth century—in fact, 1845— that a successful breech loading gun was designed. In this case, the projectile, which bore a marked resemblance to the present-day type, was placed in the gun from the breech end with a propelling charge of black powder packed in behind it, the vent being closed by a hinged door. Following this, several different types of breech closing mechanism were developed, and in England in 1854 the Armstrong breech loading gun was designed. The projectile and propelling charge, however, were still made up in separate units, and it was not until the middle of the nineteenth century that fixed ammunition was used in field guns. In early cannon the barrels were made from either bronze or cast iron, bronze being used for field guns and cast iron for large coast artillery. These two metals were subsequently abandoned, and forged steel was used in their place.

Fixed Ammunition

Fixed ammunition is the name given to that class of shells in which the propelling charge for the projectile is held in a cartridge case attached to the rear end of the projectile. In other words, the projectile, propelling charge and firing member or primer form a complete unit. The diagram at *A* in Fig. 12 shows a sectional view of a 3-inch field gun with the complete round of ammunition inserted in the breech. Here it will be noticed that the gun is chambered to receive the projectile and cartridge case, and carries a breech-block containing the striker mechanism. Upon the operation of the striker mechanism, firing pin *a* hits primer *b*, igniting the percussion cap in its head which, in turn, ignites the black powder charge in the body of the primer itself. The propellant in cartridge case *c* is now ignited, and almost instantly converted into a gas. The gas thus formed occupies a much greater volume than the original material, with the result that the projectile *e* is started on its journey through the bore of the gun.

As soon as the projectile starts forward, the copper rifling band *d* is forced into the rifling grooves in the bore of the gun, which are located in a helical path. This results in the projectile being rotated at the same time that it advances. In addition to rotating, the rifling band also centers the projectile and at the same time prevents the propelling gas from escaping past it. Modern propellants, by virtue of their ingredients, are of the slow-burning variety, and consequently the gas pressure increases, with the result that the projectile increases in velocity from the time that it leaves the breech until it reaches the muzzle of the gun. To provide for this, the rifling grooves in some guns are not made of a uniform twist, but increase in pitch as they reach the muzzle of the gun. For example, in the 3-inch American quick-firing field gun, the rifling grooves start at the breech with a twist of one turn in 50 calibers, and increase to one turn in 25 calibers

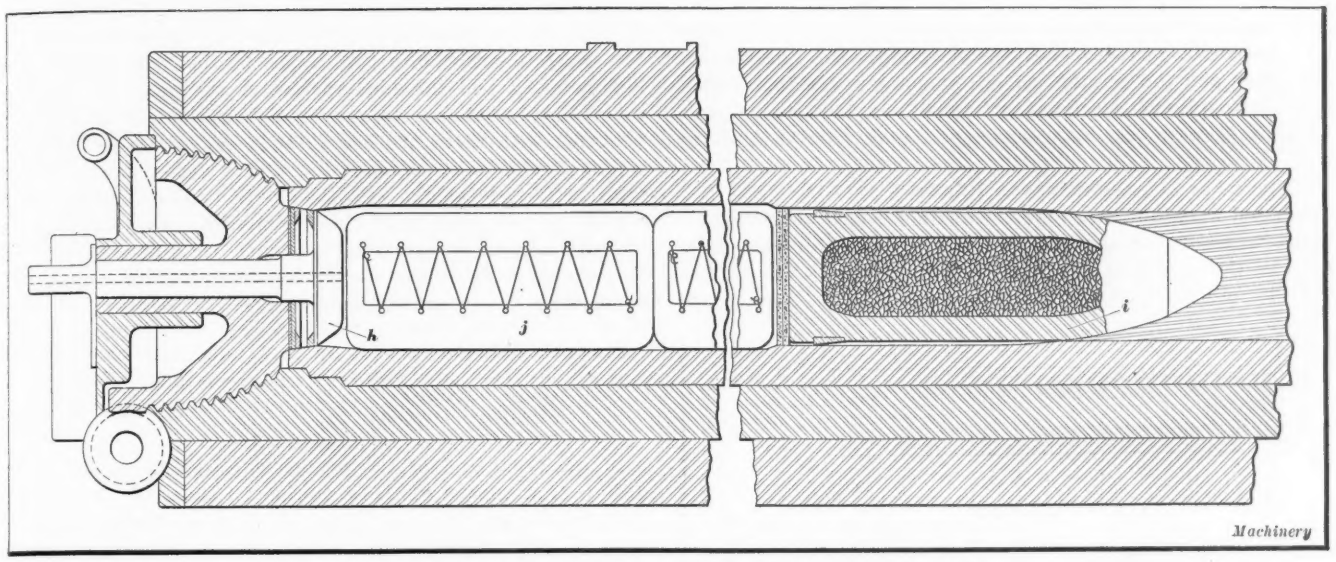


Fig. 13. Diagram illustrating Method of retaining Propelling Charge in 6-inch Gun

at a distance of 2½ calibers from the muzzle. It is therefore evident that as the velocity of the projectile is increased, the speed of rotation upon its axis is accelerated. This in part accounts for the comparatively flat trajectory of the modern high-power quick-firing gun in comparison with the older and less efficient guns.

Loading Howitzers and Mortars

A howitzer differs from a quick-firing field gun in several ways. First, the barrel is much shorter; second, no cartridge case is used (except for medium-caliber howitzers where a short case is sometimes used); third, the muzzle velocity is only about one-half that of a quick-firing gun of the same caliber; and fourth, it is used for high-angle firing, particularly against troops protected by entrenchments or other shelter. The diagram *B*, Fig. 12, shows a section through the barrel of a 4.5-inch howitzer. It will be noticed that the projectile *f* is not fixed to the cartridge case *g* but is separated from it. The difference between this cartridge case and the one shown at *A* is in length only. The howitzer cartridge case is of a length equal to about one-half the caliber, and carries a comparatively light propelling charge of smokeless powder *h*, that is held in the case by wads. Having the ammunition arranged in this manner makes possible the varying of the charge depending upon the results wanted. In larger-bore howitzers, 6-inch caliber, a charge of powder in the form of doughnuts or large disks is used. These are placed directly in the breech of the gun, and no cartridge case is used.

Another type of gun that bears a marked resemblance to the howitzer is the mortar. These are classified under two principal headings, field or trench, and coast-defense mortars. This gun differs from the howitzer only in the length of the barrel, the latter being still shorter than that of the howitzer. Fixed ammunition is never used in a mortar, and its chief application is for high-angle and vertical firing.

Loading Propelling Charges in Large-caliber Rapid-fire Guns

Fixed ammunition is used in rapid-fire guns from the 1-pounder (1.45 inch) up to and sometimes including 6-inch guns. In guns of a larger caliber than this the projectile and propelling charges are separated. Fig. 13 shows a section taken through the chamber and barrel of a 6-inch rapid-fire gun. Here it will be noticed that the projectile *i* is separate, and located between the projectile and the breech-block is a propelling charge of smokeless powder and detonating cap contained in silk bags *j*, the number of bags depending on the size of the gun and the weight of the charge put up in each. These bags are made from raw silk with the ends made double-ply, and between the two pieces at each end is placed a priming charge of black powder quilted in, in squares of about 2 inches, and uniformly spread over the surface. The charge used for propelling a projectile of this particular size of gun weighs about 24 pounds and consequently only two bags would be needed. The obturator *k* acts as a gas check and at its rear end carries the electric primer. In larger-bore guns several bags of smokeless powder are inserted. For instance, in the 16-inch American gun six bags containing a total of 666.5 pounds of smokeless powder are used. The method of igniting the powder charge is by means of either a friction or electric primer shown at *A*, *B* and *C* in Fig. 14. The primer, of course, is not a part of the propelling charge, but is held in the breech-block of the gun.

FRICTION, ELECTRIC AND PERCUSSION PRIMERS

Various types of primers are used in howitzers and field guns for igniting the propelling charges. For guns using fixed ammunition the primer is carried in the base of the cartridge case, whereas for guns firing "loose" projectiles the primer is held in the breech-block. Inasmuch as large and medium size caliber projectiles will receive attention in the following article, it would seem advisable to describe briefly two of the principal types of primers used in the breech-blocks of guns. Fig. 14 shows the common type of friction primer which may be fired either by friction or by electricity.

This primer comprises a brass case *a* held in the breech-block of the gun, and carrying an interior case *b* enclosing the firing or igniting elements. When used as a friction primer, an angular pellet *c* of friction composition is pressed into case *b* and rests on a vulcanite washer *d*. This washer supports the friction composition and prevents it from crumbling when rod *e* is pulled to ignite the primer. The inner end of firing rod *e* is loosely surrounded by serrated cylinder *g* the latter being embedded up to the serrations in the friction composition. The inner end of the firing rod is provided with a head that operates upon cylinder *g*, and these parts are securely held in place by forked lever *h* and nut *i*. (See enlarged section at *B*.)

In operation, when rod *e* is pulled, serrated cylinder *g* is drawn through the composition *c* and ignites it. The conical end of the cylinder is then drawn to its seat in the rear part of the primer and prevents the escape of gas at the rear. The flame from the friction composition passes through vents in closing nut *i* and ignites the priming charge of compressed and loose black powder in the body of the primer. The resulting explosion blows out the cemented brass cup *j* in the mouth of the primer and thus allows the flame to pass through the breech-block to the propelling charge in the breech of the gun.

In order to adapt this primer for electric firing, rod *e* is covered with an insulating cylinder *k* and enters the primer through vulcanite plug *l*. Rod *e* is in electric contact with the serrated cylinder *g*, but this is insulated from the primer body by washer *d* and the pellet of friction composition which is a non-conductor of electricity. The electric circuit is completed by platinum wire *m* that is soldered to fork *h* and nut *i*. An igniting charge of guncotton surrounds the wire.

In operation, when the primer is inserted in the gun, in-

sulated button *n* on rod *e* is grasped by an electric contact piece through which the electric current passes. The passage of the electric current heats the platinum wire, igniting the guncotton and the priming charge of powder. In this primer the frictional and electrical elements are independent and when it fails to fire by electricity it may still be fired by friction.

Percussion Primers

In fixed ammunition where the cartridge case forms a unit with the projectile, the firing is done by means of a primer held in the cartridge case. *D* in Fig. 14 shows the primer used in the head of American 3-inch cartridge cases. This

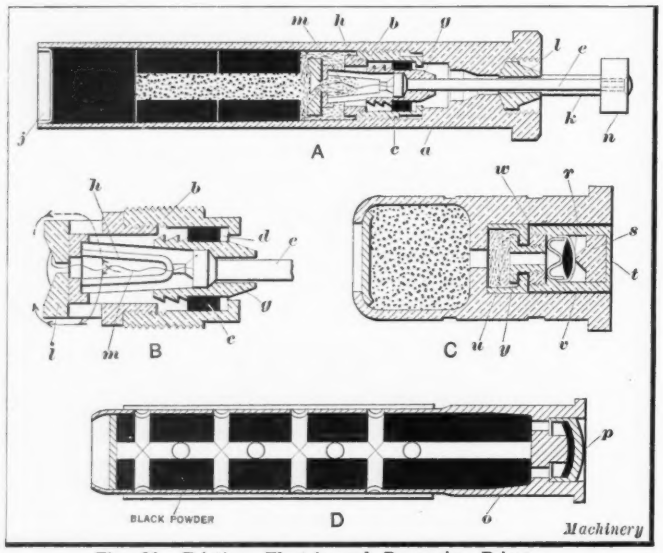


Fig. 14. Friction, Electric and Percussion Primers

is known as the 110-grain percussion primer, and consists of a brass case *o* resembling in shape a small-arms cartridge case, in which a percussion cap is held. The head or rear end of the primer case is countersunk to form a cup shaped recess in which the percussion primer proper *p* is located. The latter consists of a cup, anvil and percussion composition. The percussion composition is composed of the following ingredients:

Ingredients	Per Cent
Chlorate of Potash	49.6
Sulphide of Antimony	21.5
Glass (ground)	16.6
Sulphur	8.7

Owing to the danger involved in the handling of mixtures containing fulminate of mercury, the Frankford Arsenal has abandoned this ingredient and substituted the ingredients given above for use in the service primers.

The percussion cap recess is connected with the interior of the primer case by two small vents. The body of the case contains 110 grains of black powder that constitutes the rear "priming" or igniting charge for the smokeless powder propellant. This black powder is inserted in the case under a pressure of 36,000 pounds per square inch, and is pressed into the primer body around a central wire which is then withdrawn leaving a longitudinal hole the full length of the powder charge. Eight radial holes are then drilled through the primer body and compressed powder, thus affording sixteen vents for the free exit of the black powder flames to the smokeless powder charge. After filling the case, the front end is closed by a cardboard wad covered with shellac and the radial perforations are covered by a tin foil wrapper so as to retain any loose black powder and exclude moisture.

In action, the firing pin hits the percussion cap and explodes it. This ignites the black powder charge, and the flames from the latter shoot out through the vents in the case and ignite the smokeless powder charge. In order to make the combustion of the smokeless powder complete, a second igniting or priming charge is generally used. In the 3-inch shell this additional charge consists of ¼ ounce of black powder which is contained in a disk shaped bag placed in the case directly in front of the smokeless powder charge.

Another percussion primer which differs considerably from that illustrated at *D* in Fig. 14 is shown in Fig. 15. This particular primer is used in British 18-pound cartridge cases. It comprises a brass cup *A*, threaded on the external diameter so as to screw into the pocket in the head of the case, and recessed and threaded to receive the anvil *B*. This, in turn, is counterbored to receive a brass ball *C* and is also provided with three fire holes. It is backed up by means of a plug *D*, the latter being sealed with a paper disk *E* secured with Pettman's cement. Seated on the head of anvil *B* is the percussion composition *F* which is pressed into the form of a cup and inside of which is located a tin foil washer. The percussion composition, known as the 1.2-grain composition consists of the following ingredients:

Ingredients	Per Cent
Sulphide of Antimony	54.5
Chlorate of Potash	36.5
Glass (ground)	3
Powder (mealed)	3
Sulphur	3

In the front end of the primer enclosed by brass closing disk *G* is a charge of RFG[2] powder. Separating the closing disk and the powder is a paper disk *H* secured with Pettman's cement. The closing disk *G* is held in place by spinning over the front edge of cup *A*.

In action, the firing pin comes directly in contact with the percussion cap *F*, exploding it and causing the flames to pass through the vents in anvil *B* and plug *D*. Paper disk *E* is thus ignited together with the powder charge in the front end of the primer. The resulting pressure forces out the center of closing disk *G* which is weakened by six radial slots. The flame then passes to the secondary powder charge in the base of the cartridge case, thus effecting complete combustion of the propelling charge. In order to prevent the escape of gas back through the vents in the primer before complete combustion has taken place, soft brass ball *C* is inserted in the anvil. As soon as the powder in the front of the primer is ignited the resultant back pressure forces the ball into the circular seat in the anvil and effectively prevents the further escape of gas.

Combination Electric and Percussion Primer

The United States Navy uses a combination electric and percussion primer in rapid-fire guns of the type shown at *C* in Fig. 14. When fired by percussion the percussion cap *r* is not struck directly by the firing pin, but the point of the pin forces in the head of the cup *t* and this, in turn, advances plug *s*. The method of igniting this primer electrically is as follows: Ignition is effected through the brass cup *t* to which one end of the platinum wire *u* is soldered. A small quantity of guncotton surrounds this wire. Electric contact is made with cup *t* by the insulated firing pin of the gun. This cup is insulated from the body of the primer by the

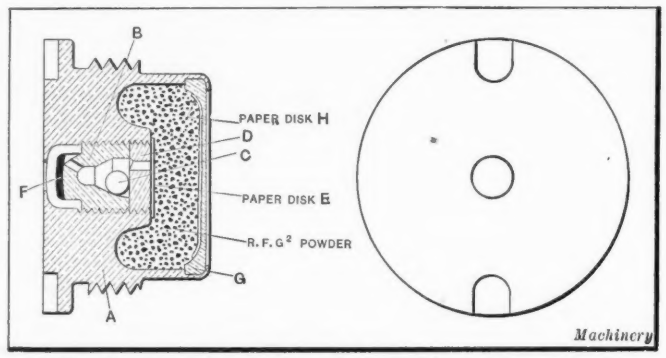


Fig. 15. Percussion Primer used in British Cartridge Cases

cylinder *w* and bushing *v*, both made of vulcanite. The brass contact bushing *y* to which the other end of the platinum wire is soldered completes the electrical connection.

EXPLOSIVES, DETONATORS AND FULMINATES

Reference to Fig. 3 will show that a high-explosive shell of the fixed-ammunition type comprises four principal parts, namely, the projectile itself, fuse (detonating) cartridge case and primer. The projectile carries the high-explosive which when detonated produces such a powerful shattering effect that the steel shell is blown into atoms. The high-explosive

in the shell is detonated by other very powerful explosives that are contained in the gaine of the detonating fuse. In the fuse proper as many as four different classes of explosives are used, namely, fulminate of mercury, black powder, picric acid and other compounds of a similar nature so combined as to make their explosive effect of different strengths.

The cartridge case carries a propellant, usually nitro-cellulose or nitro-glycerine, that is put up in the form of flakes, long tubes, perforated grains or flat strips. It also contains either one or two charges of common black powder. One charge is located between the smokeless powder and the projectile. The other is located next to the primer pocket, and assists the priming charge in effecting complete combustion of the propelling charge. The last or fourth member is the primer. This usually contains two explosive agents, namely, fulminates or chlorates, and black powder.

Classification of Explosives

The explosives used in high-explosive shells, cartridge cases, fuses and primers, may be divided into three general classes, namely, (1) progressing or propelling explosives—known as "low" explosives; (2) detonating or disruptive explosives—known as "high-explosives"; (3) detonators, known as "fulminates" or "chlorates." The first of these includes black gunpowder, smokeless powder, and black blasting powder; the second, dynamite, nitro-glycerine, guncotton, etc.; the third, fulminates and chlorates. In all classes of explosives, the effect of the explosion is dependent upon the quantity of gas and heat developed per unit of weight, the volume of the explosion, the rapidity of reaction and the character of

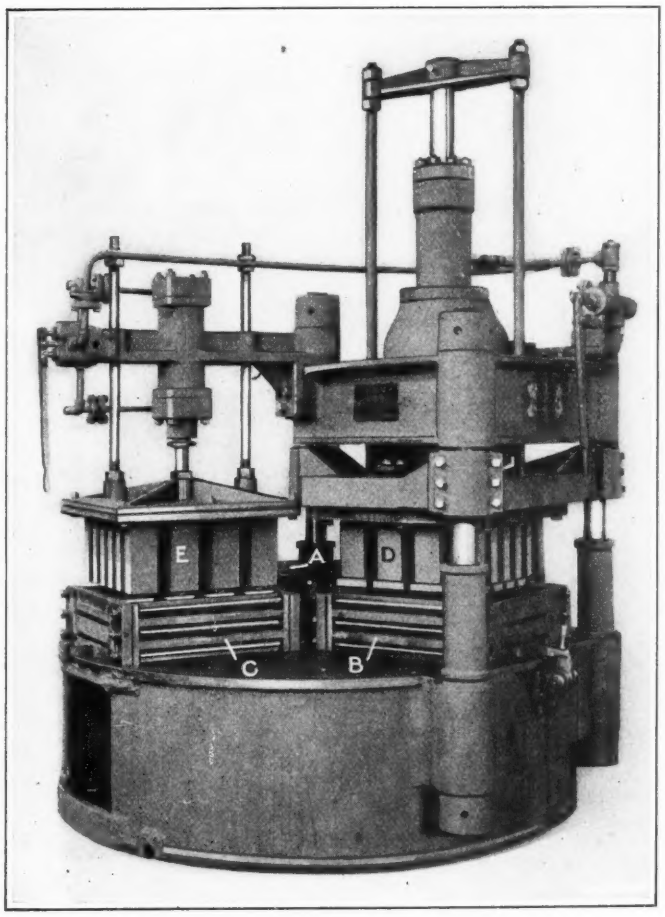


Fig. 16. Boomer & Boschert Guncotton Press

the confinement, if any, in which the explosive charge is placed.

Black Gunpowder

The most common of all explosives is black gunpowder. The earliest known use of gunpowder was in the sixteenth century and at that time it was used in the form of fine powder or dust. No marked improvement was made in gunpowder until 1860, when General Rodman of the Ordnance Department of the United States Army discovered the principle of progressive combustion. This consisted in using larger grains of greater density so that the rate of combustion could be more uniformly controlled. The increased density diminished the rate of combustion, so that black powder in this form developed less gas in the first instant of combustion, and the volume of gas increased as the projectile moved through the bore of the gun. Black gunpowder is usually made up of a mechanical mixture of niter, charcoal and sulphur in the proportions of 70 parts niter, 15 charcoal and 10 sulphur. The niter furnishes the oxygen to burn the charcoal and sulphur, and the charcoal furnishes the carbon, whereas

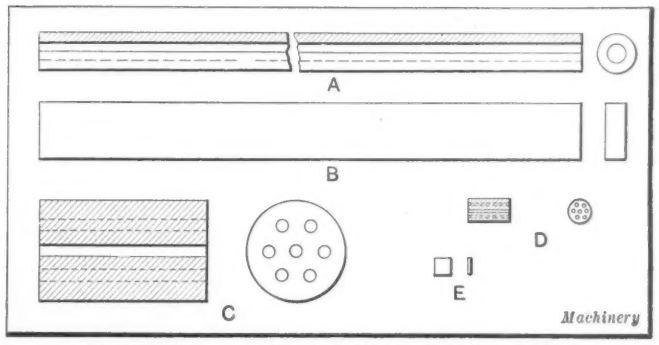


Fig. 17. Form and Size of Grain for Smokeless Powders

the sulphur gives density of grain to the powder and lowers its point of ignition.

The manufacture of black gunpowder is comparatively simple. The ingredients are first ground and pulverized, after which the correct proportions of each ingredient are intimately mixed in an incorporating mill consisting of two heavy iron wheels mounted to run in a circular bed. The product is called a "mill cake." The "mill cake" is then subjected to pressure in a hydraulic press and forms what is known as a "press-cake." The cake from the press is then broken up into grains by passing through rollers and the grains are graded by passing through sieves. The grains are either glazed by rotating in drums with or without graphite, which gives a uniform density to the surface. When special forms are to be given to the powder, dies are used to obtain the desired shape. This is done after the powder has been thoroughly mixed and formed into "press-cake."

Black powder or gunpowder is used in primers, fuses, and also in the cartridge case as an additional priming charge for completing the combustion of the propelling charge. In the early use of high-explosive shells, black gunpowder was also used as a bursting charge, but in recent years this has been supplemented by other and more powerful high-explosives.

Smokeless Powder

The modern smokeless powders are put up into many different forms, but all have the same base, namely guncotton. The invention of guncotton is credited to a German chemist Schoenbein who, in 1846, discovered a substance that he called "cotton powder." Further improvements were later made in the manufacture of guncotton by General Von Lenk and Sir Frederick Abel. Two of the principal smokeless powders are nitro-cellulose and nitro-glycerine. As has been previously stated, the base of these explosives is guncotton, but the final stages in their manufacture are handled in a somewhat different manner. For instance, in the manufacture of nitro-glycerine, a mineral jelly is added.

Manufacture of Guncotton

In the manufacture of guncotton, the short fiber of the cotton which is detached from the cotton seed rather late in the process of removal is used. After being bleached and purified, this is run through a picker which opens up the fiber and breaks up any lumps. It is then thoroughly dried and is ready for nitration. The most generally used method of nitration consists in putting the cotton into a large vessel nearly filled with a mixture of nitric and sulphuric acid. The sulphuric acid is used to absorb the water developed in the process of nitration which would otherwise dilute the nitric acid too much. After a few minutes immersion the pot is rapidly rotated by machinery and the acid permitted to es-

cape. The nitrated product is then washed in a preliminary way, removed from the nitrator and repeatedly washed and boiled to remove all traces of free acid. In the process of nitration, the cotton has not changed its appearance, but has become a little harsh to touch. The keeping qualities of smokeless powder are dependent upon the thoroughness with which it is purified. At this stage of the manufacture at least five boilings, with a change of water after each boiling, covering a total of forty hours, is necessary. Following this preliminary purification the cotton is cut up into still shorter lengths by being repeatedly run between cylinders carrying revolving knives. This operation is necessary, as the cotton fibers are hollow tubes, making it difficult to remove the traces of acid from the interior unless they are of very short lengths. After being pulped, the cotton is given six more boilings with a change of water after each, followed by ten cold water washings. The completed material is then known as guncotton or pyro-cellulose.

Before adding the solvent (acetone), the guncotton must be completely freed from water. This is partly accomplished in a centrifugal wringer, but is completed by compressing the guncotton into a solid block and forcing alcohol through the compressed mass. To convert the guncotton or pyro-cellulose into nitro-cellulose, ether is added to the pyro-cellulose thus impregnated with alcohol, the relative proportions being about two parts of ether to one part of alcohol, by volume. After the ether has been thoroughly incorporated in a kneading machine, the material is compressed into blocks. This is generally accomplished in a hydraulic press; a machine especially designed for this purpose is shown in Fig. 16. This press is built by the Canadian Boomer & Boschert Press Co., Ltd., and is capable of exerting a pressure of 150 tons on the material. Reference to this illustration will show that this press has three sets of dies *A*, *B* and *C*, which are held on a separate column on the press upon which they revolve; also two sets of punches or male dies, set *D* being used for pressing the cotton, and the other set *E* for ejecting it after pressing. The base of the machine is of cast iron, through which a number of small holes are drilled to allow drainage of the water from the cotton. The chief advantage of this press is that, being provided with three sets of dies, it is possible to load one set of dies while another is being pressed and the cotton ejected, thereby making the operation practically continuous. This press is operated by a pump giving a pressure of 1500 pounds per square inch.

The size of the compressed blocks varies; in some cases these blocks are made 10 inches in diameter by 15 inches long, or are made of square section. In this operation the pyro-cellulose loses the appearance of cotton and takes on a dense horny appearance, forming what is known as a colloid. The colloid is then transferred to a finishing press where it is again forced through dies and comes out in the form of long strips or rods, which are cut into grains of the required length. The grains are then subjected to a drying process, which removes nearly all the solvent (acetone) and leaves the powder in a suitable condition for use. The drying process is a lengthy one, taking as much as four or five months for the larger grain powders. Upon completion, the powder is blended and packed in air-tight boxes.

Cordite

Cordite is the form in which smokeless powder is used by the English government and it is composed of 58 per cent nitro-glycerine, 37 per cent guncotton, and 5 per cent vaseline. The vaseline serves to render the powder waterproof, and improves its keeping qualities. For use in cannon, cordite is made into long thick rods that are tubular in form or in the form of perforated cylinders. For heavy guns a powder called cordite M. D. has lately been introduced. This composition consists of 30 parts nitro-glycerine, 65 parts guncotton, and 5 parts vaseline. The reduction in the percentage of nitro-glycerine was made necessary because of the desire to lower the temperature of the explosive and the consequent erosion in the bore of the gun.

Forms of Smokeless Powder Grains

The form of grain in which smokeless powder is made differs in various countries. In foreign countries, especially in Germany, nitro-cellulose in the form of long tubes similar in shape to macaroni are used. Fig. 17 shows a few of the many forms in which smokeless powder is put up. *A* shows a tube which is sometimes as long as two feet. Usually, however, the nitro-cellulose when put up in this form is about the length of the chamber in the gun or long enough to about fill the cartridge case. Another way in which nitro-glycerine smokeless powder is put up is in slab form, as shown at *B*. In cartridges used by the French government, this slab is 0.0195 inch thick and ½ inch wide, and about 5 to 6 inches long. This form of smokeless powder is also used by the Italian government. In the United States Army service, the nitro-cellulose powder is put up in the form of cylindrical grains, as shown at *C* and *D*, which are provided with seven longitudinal perforations, one central and the other six equally distributed midway between the center of the grain and its circumference. A uniform thickness of web is thus obtained. The length and diameter of the grain vary in powders for different guns, the size increasing with the caliber of the gun. The length is unimportant, the web between the perforations being the factor that receives first attention. For the 3-inch rifle, the grain has a length of about ⅜ inch, and a diameter of 0.195 inch as shown at *D*. For the 12-inch rifle, the length is 1½ inch, and the diameter ⅞ inch as shown at *C*. For smaller guns, the grains are in the form of thin flat squares, as shown at *E*. When used in howitzers or mortars, smokeless powder is put up sometimes in the form of tubes, solid and tubular rods, flat disks, and rolled sheets.

High-explosives—Shell Fillers

High-explosives which are generally termed "shell fillers" are known by various tradenames, such as emmensite, lyddite, melenite, maximite, nitro-benzole, nitro-naphthaline, shimose, trintitrotoluol, etc. The base of such explosives as emmensite, maximite, lyddite, melenite and shimose is picric acid, which is secured from coal tar, subjected to fractional distillation. The liquid which comes off when this is raised to a temperature of 150 degrees C. is called "light" oil, and when these light oils have been again distilled, the next fraction or "middle" oil is phenol or carbolic acid. This substance when nitrated gives off picric acid, or as it is sometimes called trinitrophenol. As a shell filler, this explosive may be pressed into the explosive cavity or melted and poured in. It forms an unstable metallic salt when coming in contact with the body of the shell, and consequently in assembling or in pouring the melted acid in the shell it is necessary to first coat the cavity thoroughly with a non-metallic paint. Picric acid is the basis of many of the foreign shell fillers given above. The difference in composition of these various explosives usually consists in the addition of an ingredient (camphor, nitro-naphthaline, trinitrotoluene, etc.) which are introduced to reduce the melting point.

At present, the most popular or generally used shell filler is T. N. T. (trinitrotoluol). Although the explosive force of trinitrotoluol is somewhat less than that of picric acid, the pressure of the latter being about 135,820 pounds per square inch, as against 119,000 pounds for trinitrotoluol, its advantages more than compensate for the difference. Trinitrotoluol is obtained by the nitration of toluene obtained from crude benzol distilled from coal tar and washed out from coal gas. The crude benzol contains roughly:

Constituent	Per Cent
Benzine	50
Toluene	36
Xylene	11
Other Substances	3

Toluene, to be used for the manufacture of trinitrotoluol, should be a clear water-like liquid, free from suspended solid matter, and having a specific gravity not less than 0.868 nor more than 0.870, at 15.5 degrees C. Trinitrotoluol, when pure, has no odor, and is a yellowish crystalline powder which darkens slightly with age. It cannot be exploded by flame or strong percussion and a rifle bullet may be fired through it without any effect. When heated to 180 degrees C. it ignites and burns with a heavy black smoke; but when detonated by a fulminate of mercury detonator, it explodes with great force, giving off a black smoke. Shells containing this explosive first used on the Western battlefront

were given such names as "coal-boxes," "Jack Johnson," "Black Maria's," etc., by the Allies.

In the United States service, picric acid, explosive "D" and trinitrotoluol are used as shell fillers. High-explosive shells containing explosive "D" with a small charge of picric acid surrounding the detonator are used, and in high-explosive shrapnel, trinitrotoluol is used as a matrix. Trinitrotoluol may also be detonated with a fulminate of mercury detonator augmented by a small amount of trinitrotoluol in loose crystals.

The Russians and Austrians use a high-explosive known as ammonal, in which 12 to 15 per cent of trinitrotoluol is mixed with an oxidizing compound, ammonium nitrate, a small amount of aluminum powder and a trace of charcoal. This high-explosive gives somewhat better results than plain trinitrotoluol, but has the one disadvantage of easily collecting moisture, and consequently must be made up in air-tight cartridges. The British are now using an improved compound of this character, which is so prepared that trouble is not experienced with the collection of moisture.

Fulminates and Chlorates

The action of fulminates is more powerful than either the low- or high-explosives described. They can be readily detonated by slight shock or by the application of heat and are used in primers for setting off the propelling charge in the cartridge case, and in fuses, either of the plain percussion or combination time and percussion types. The most common fulminate is made by dissolving mercury in strong nitric acid and then pouring the solution into alcohol. After an apparently violent reaction, a mass of fine, gray crystals of fulminate of mercury is produced. The crystalline powder thus produced is washed with water to free it from acid, and is then mixed with glass ground to a fine powder. Because of its extreme sensitiveness to heat produced by the slightest friction, it is usually kept soaked in water or alcohol until needed.

A common mixture of fulminate of mercury for use in primers contains the following ingredients:

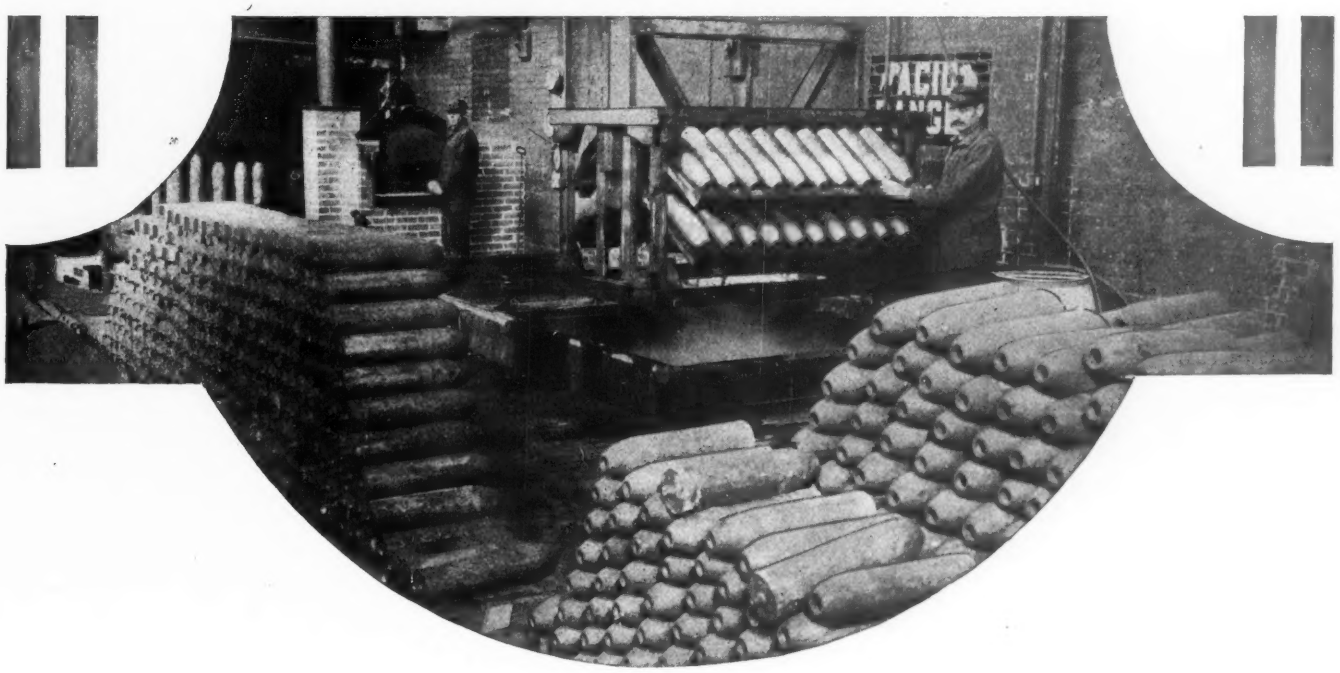
Ingredients	Per Cent
Fulminate of Mercury	50
Chlorate of Potassium	20
Glass (ground)	30

The ground glass must be sifted through a sieve having 100 meshes to the linear inch. To the mixture given is added 0.25 per cent of tragacanth gum and a trace of gum arabic. This composition is placed in the primer while moist; after compression the primer cap is dried for ten days at a temperature of 88 degrees F., and for twelve days at 111 degrees F. Then the exterior surface of the parchment covering the mixture is coated with a thick varnish composed of 0.891 gallon of 95 per cent alcohol, 2.75 pounds of shellac, and 0.5 pound resin. The varnished primers are dried at a room temperature for five or six days.

In primers used in British, American and some of the foreign cartridge cases, the fulminate of mercury detonator is not used, but is replaced by a composition generally called chlorate of potassium. A common mixture includes the following ingredients:

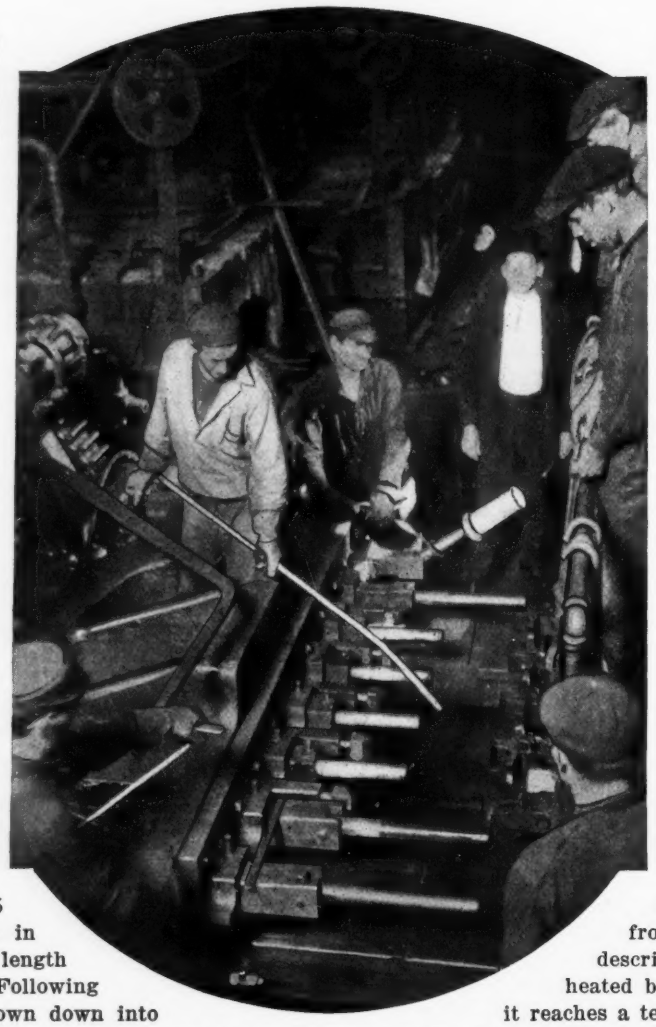
Ingredients	Per Cent
Chlorate of Potassium	49.6
Sulphide of Antimony	25.1
Glass (ground)	16.6
Sulphur	8.7

This composition is less dangerous to handle than fulminate of mercury, and also has much less erosive effect on the bore of the gun.



FORGING HIGH-EXPLOSIVE SHELLS

THE preliminary stages in the forging of a high-explosive shell do not differ materially from those through which a shrapnel shell passes as described in the April number of MACHINERY. Since the article referred to has been published, however, many improvements have been effected, and a variety of new methods of accomplishing the work have been devised. At present, the preliminary stages in the manufacture of high-explosive shell forgings are carried on in one of two ways: The first is to use hot-drawn bar stock which is cut up into billets of the required length in cutting-off or shearing machines; and the second is to cast billets, varying in length and diameter depending on the size of shell. These billets are then cut up into blanks of the required lengths for forging.



In one of the prominent Canadian plants engaged in this work, billets for British 4.5 high-explosive shells are cast in ingot molds to 33 inches in length by 4 15/16 inches diameter. Following the casting, the billets are thrown down into the sand and allowed to cool off. The next operation is to cut the billets up into sections 9½ inches long. This is done in a lathe where the bar is partially severed at the required points and then taken out of the lathe and broken up. The teats are finally cut off on a planer, leaving the blanks in a suitable condition for forging. When the forgings are made from bar stock, cut off from hot-rolled bars, the high-power cutting-off machine is generally used, as will be described later.

Forging British 4.5 High-explosive Shell Blanks

Several different methods have been used in the Canadian plants in forging high-explosive shell blanks. One prominent concern, in the early stages of this work, adopted the method shown in Fig. 18 for forging 4.5 high-explosive shell blanks. To start with, a blank 4 13/16 inches in diameter by 9 inches long was used. This was heated in a furnace to 1950 degrees F. for about 45 minutes, and when it had acquired the correct forging temperature it was taken out and dropped into the die *a* shown at *A* in Fig. 18. One operator then quickly placed the guide *b* over the die and put in the punch *c*. The steam hammer was then operated and punch *c* started into the billet. When the punch had been driven in far enough to get a good start, it was removed, cooled off in water, guide *b* removed, the punch replaced, and three or four more blows delivered, finishing the billet as shown at *B*. The next operation was performed in a hydraulic press of 500 tons' capacity. The billet was again heated to the correct temperature, placed in the die as shown at *C* and drawn up to the shape shown at *D*. This was done in one stroke of the press. A final forging or drawing operation was then accomplished as shown at *E* and *F*. As will be noticed in this case, the forging is forced through two dies that are 5 1/16 and 4 15/16 inches in diameter, respectively. The forging as completed was 4⅞ inches diameter, by 12¾ inches long, with a base 1½ inch thick. After the forgings were removed from the die, they were allowed to cool, after which they were inspected.

The method just described has been improved upon somewhat by the concern using it. The new method is illustrated in Figs. 19 and 20. In Fig. 20, is shown the 350-ton hydraulic press used to complete the forging in one "shot." The billet, as will be seen from Fig. 19, is 4.8 inches diameter and 9½ inches long. This is cut off from a cast billet, as previously described, and is placed in a furnace heated by fuel oil, where it is left until it reaches a temperature of about 1900 to 1950 degrees F. It is then pulled out by a long bar with a bent end, dropped onto a sheet-iron slide, and carried over near the hydraulic press. Here it is quickly picked up by one of the operators and placed on a block, where all the excessive scale is removed by means of a scoop. It is then dropped into the die and the press operated. In this particular case, no bushing or guide is used to center the punch, and it is allowed to descend freely into the heated billet, extruding it around the punch. The punch and die are kept lubricated with a mixture of graphite and oil and are also cooled by a stream of water after each billet has been pierced. In this operation the forging is drawn out in one "shot" from 9½ to 13¾ inches in length, and sometimes it even exceeds 14 inches. The shape of the die and the size and shape of the finished forging are shown at *B* in Fig. 19. The production on this operation is 220 in eight hours, and four men are required, three to attend to the press and one to the furnace.

Forging Russian 3-inch High-explosive Shell Blanks

A very complete and interesting forging equipment is used by the Laconia Car Co., Laconia, N. H., for turning out 3-inch Russian shrapnel forgings at the rate of 3000 per day. In this plant the bulldozer is used for performing both the piercing and drawing operations on the forgings as will be described later. Russian high-explosive shell forgings are made from steel containing 50-point carbon and are also high in manganese. Great difficulty has been experienced in cutting these bars off with cold saws, and the Laconia Car Co. has

employed with success a Cleveland Punch & Shear Co.'s shear, shown in Fig. 22. This machine is provided with cutting-off blades made from special shear blade steel, which are formed to the shape of the bar. About 3000 pieces are cut off between grindings of the shear blade. The bars are about 20 feet long and 3¼ inches in diameter, and the billets are cut off to 6¾ inches in length. The machine makes about five strokes per minute.

After cutting off, the billets are placed in a furnace of the type shown in Fig. 21, which has been built especially for this work by this company. Here the blanks are heated to 2250 degrees F. These furnaces are of the open-hearth down-draft type, built to the dimensions given in the illustration. The heating space is 18 inches at the highest point of the arc, and 3 feet wide by 5 feet 6 inches long. Each furnace is

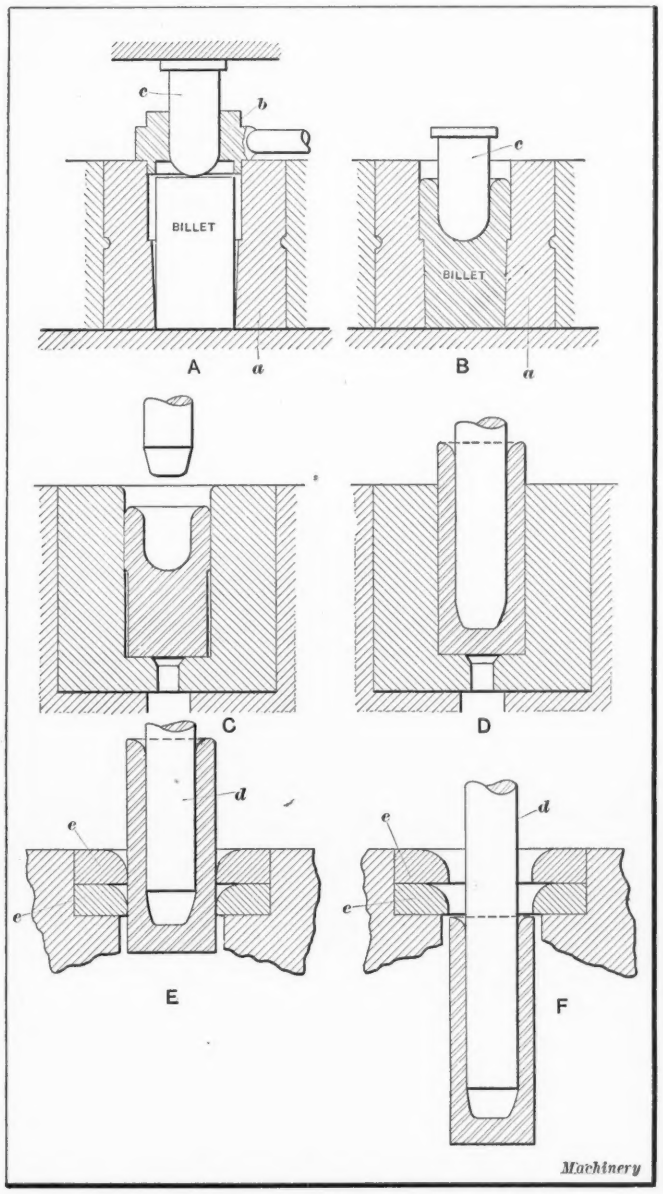


Fig. 18. Three-operation Method of making 4.5 British High-explosive Shell Forgings

provided with two double burners, and ½-pound air pressure from a Sturtevant fan is sufficient to operate them. In maintaining a temperature of 2250 degrees F. only 9 gallons of crude oil is consumed per hour by each furnace. With these furnaces, a temperature of 2850 degrees F. can be obtained without trouble, but the temperature required for this work seldom exceeds 2300 degrees.

The forging is done on a Williams & White size 9-U bull-dozer, as shown in the initial illustration and the close-range view Fig. 23. This machine is capable of making six strokes per minute and a forging is completed in two strokes. The piercing punches and dies shape the piece, as shown at *B* in Fig. 25, whereas the drawing punches and dies complete the forging as shown at *C*. By referring to Fig. 23 it will be noticed that the piercing and drawing dies are held in a spe-

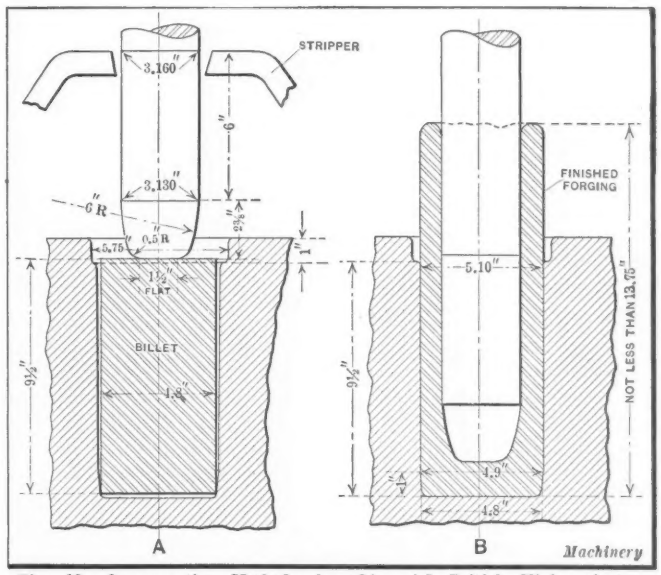


Fig. 19. One-operation Method of making 4.5 British High-explosive Shell Forgings

cial holder fastened to the bed, whereas the punches are held on the cross-head. The two outer punches at each side, *A*, *B*, *C*, and *D* are the drawing punches, whereas the four inner ones *E*, *G*, *H*, and *I* are for piercing. There are seven men in the forging team for each machine; one attends to the furnace, one removes the forgings from the furnace, the third man starts and stops the bulldozer and looks after the machine. On each side of the machine there are two tool-men and two forgers. This machine will carry on a piercing and drawing operation at the same time.

The method of operation is as follows: The forge-man gets the hot billet from the furnace-man and puts it in one of the two piercing dies on his side of the machine. One blow partly forms it, and he then passes it on to one of the two drawing punches at his side, the tool-man swinging the punch up to permit the forging to be removed and at the same time greasing the punch. The object of having two piercing and two drawing punches is to allow one to cool while the other is being used, the two sides of the machine being used alternately.

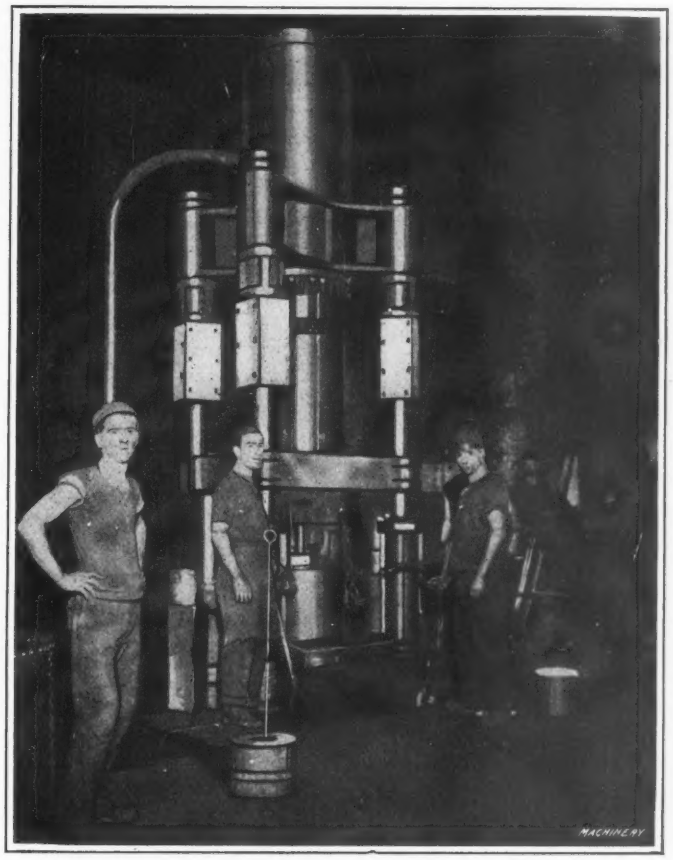


Fig. 20. Forging British 4.5 High-explosive Shells in One Operation

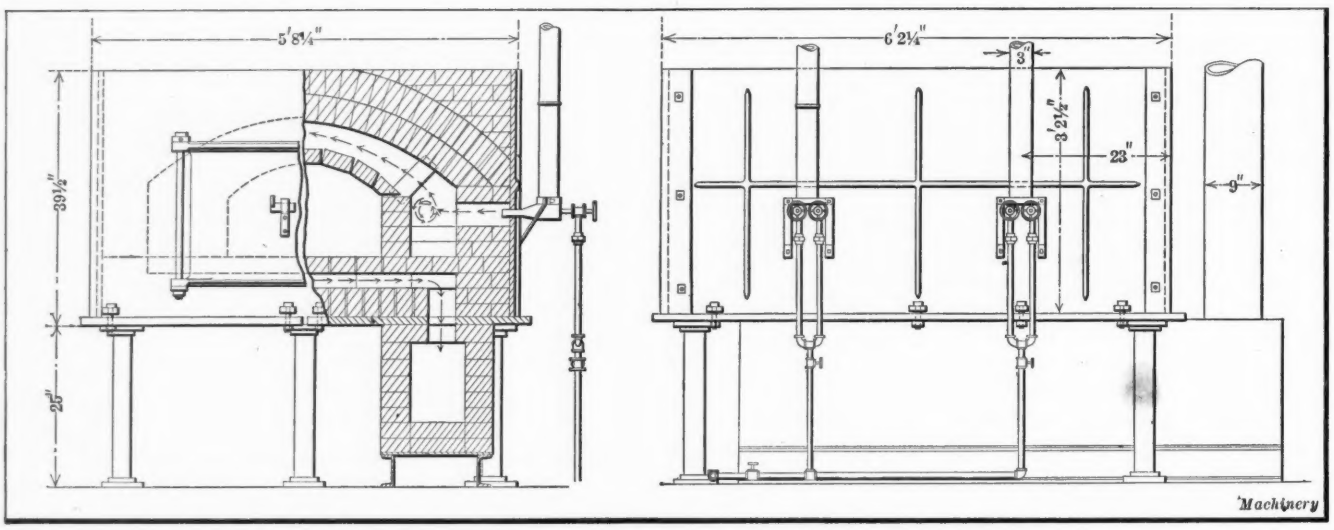


Fig. 21. Furnace built by the Laconia Car Co., for heating High-explosive Shell Blanks for Forging

Fig. 23 shows clearly how the punches and dies are held. It will be noticed that the piercing punches are shorter than the drawing punches and that they pass through the strippers *K*, which remove the pierced forging from the punch, as the forging is not forced through the die in being pierced. The strippers are operated by the V-shaped members *J*, which come up between them and close them in on the punch.

The piercing punches are made from special vanadium steel, and 5000 forgings are made before the punches are worn out. The drawing punches are also made from vanadium steel and turn out about 3000 before giving out. For the dies, white cast iron is used, and 4000 is the limit obtained from one die. The drawing dies are made of chilled cast iron and have a life of from 1800 to 2000 forgings. The forgings are not annealed, but are piled up in a sand-box and allowed to cool slowly. One team of men and one machine will produce 500 forgings in eight hours without any trouble.

Fig. 22. Cutting off Blanks for Russian 3-inch High-explosive Shell Forgings in a Shearing Press

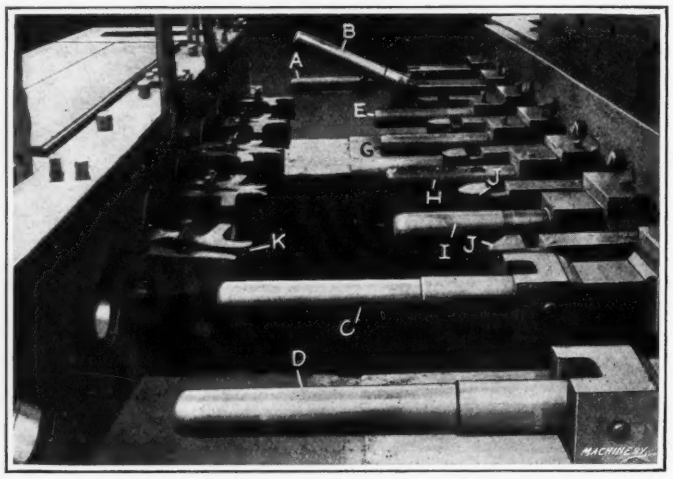


Fig. 23. Arrangement of Dies and Punches on Williams & White Bulldozer for forging Russian High-explosive Shells

Forging Large-caliber High-explosive Shells

At present there are two chief methods of making large high-explosive shell blanks. One of these does not differ materially from that used in the production of forgings for medium-caliber shells. In the large-caliber shells the hole in the nose—when the shell carries a nose fuse—is small in proportion to that used in the small-caliber forgings. Consequently, a greater amount of metal is turned in at the nose.

One method of making these shells is shown in Fig. 24. The preliminary stages in the process shown by the diagram at *A*, *B*, *C*, *D* and *E* are the same as for making an ordinary forging. For instance, the billet is pierced, as shown at *A*, *B*, and *C* by being forced over punch *d* by punch *c* acting through die *a*. The frame carrying die-holder *b* then rises, and stripper-plate *e* removes the pierced forging from the punch as shown at *D*. The next step consists in drawing the pierced forging through dies, as shown at *E*. The forging is now heated on the nose end, taken to another press and dropped in the die as illustrated at *F*. The nosing-in punch then descends, as shown at *G*, and closes in the open end of the forging to the shape shown at *H*. Further operations consist in drilling out the nose for the fuse, threading it, etc., for the reception of the fuse. In

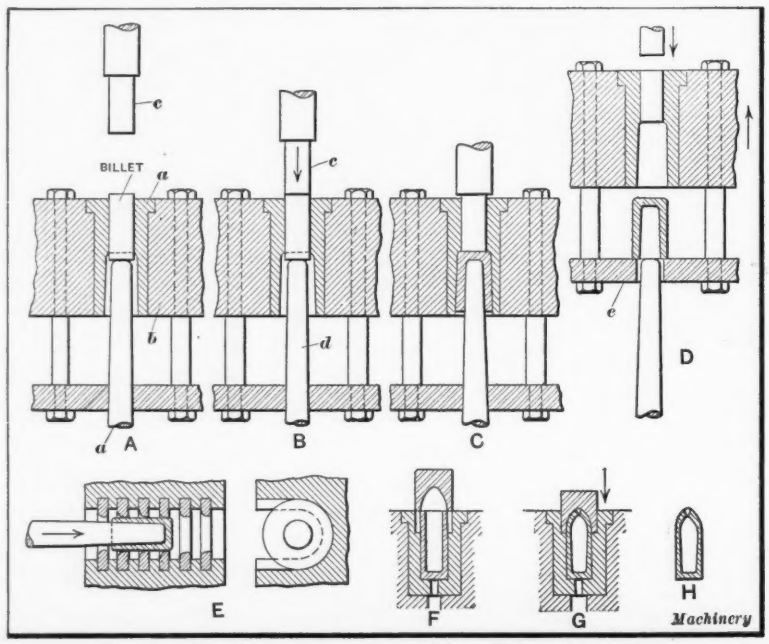


Fig. 24. Method of forging Large-caliber High-explosive Shells

this class of forging no machining whatever is done in the cavity of the shell.

Another method of making large-caliber shell forgings which are open both on the nose and base ends is to use seamless drawn tubing. The first operation consists in cutting off a piece of tubing of the required length. It is then heated on one end and taken to a hydraulic press, where, by means of a properly shaped die and punch the base end is upset in toward the center. The forging is next heated on the opposite end, taken to another press and nosed-in in a manner similar to that shown at *G* in Fig. 24. This method of making large forgings has the advantage of saving considerable material, both in the preliminary stages and in the final machining operations.

Forging Armor-piercing Shells

Armor-piercing shells are always made with a solid nose. The reason for this is that this type of shell is used for piercing hardened armor, which, of course, calls for great strength in the nose. One method of making armor-piercing shells which is also applicable to the production of the type of high-explosive shell used by the U. S. government, is shown in Fig. 26. This method does not differ in principle from that shown in Fig. 19, except that the shell is forged with the nose instead of the base down. Usually, the punch is not relied upon to center in the billet accurately, and when this is the case, a centering bushing is used. The bushing is inserted in the top of the die, the punch is allowed to descend for a short distance into the heated billet and is then raised, the bushing is removed and the punch again advanced. When making a forging in the manner shown in Fig. 26, it is usually necessary to eject the forging and make it follow the punch, from which it is removed by a stripper as the punch rises.

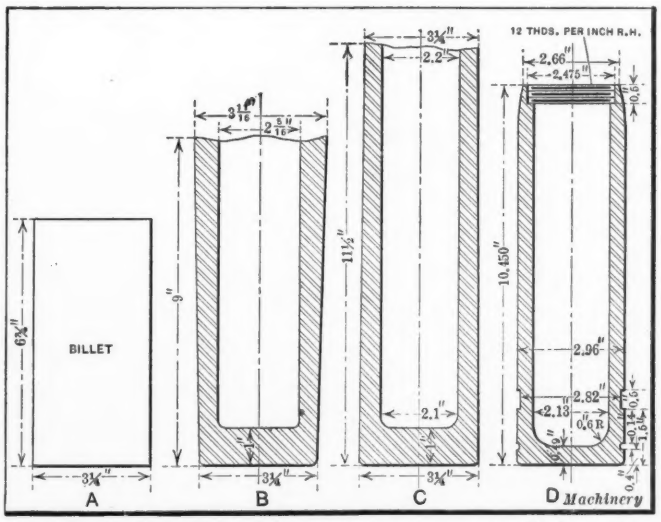


Fig. 25. Russian 3-inch High-explosive Shell from the Blank to the Finished Shell

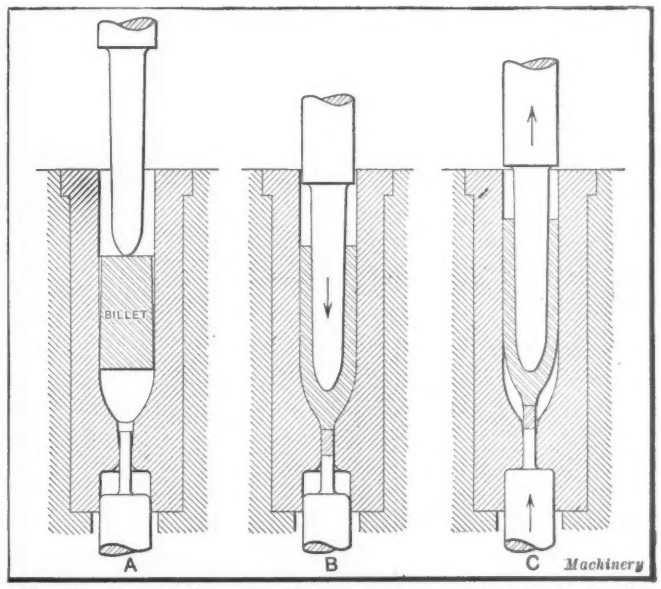
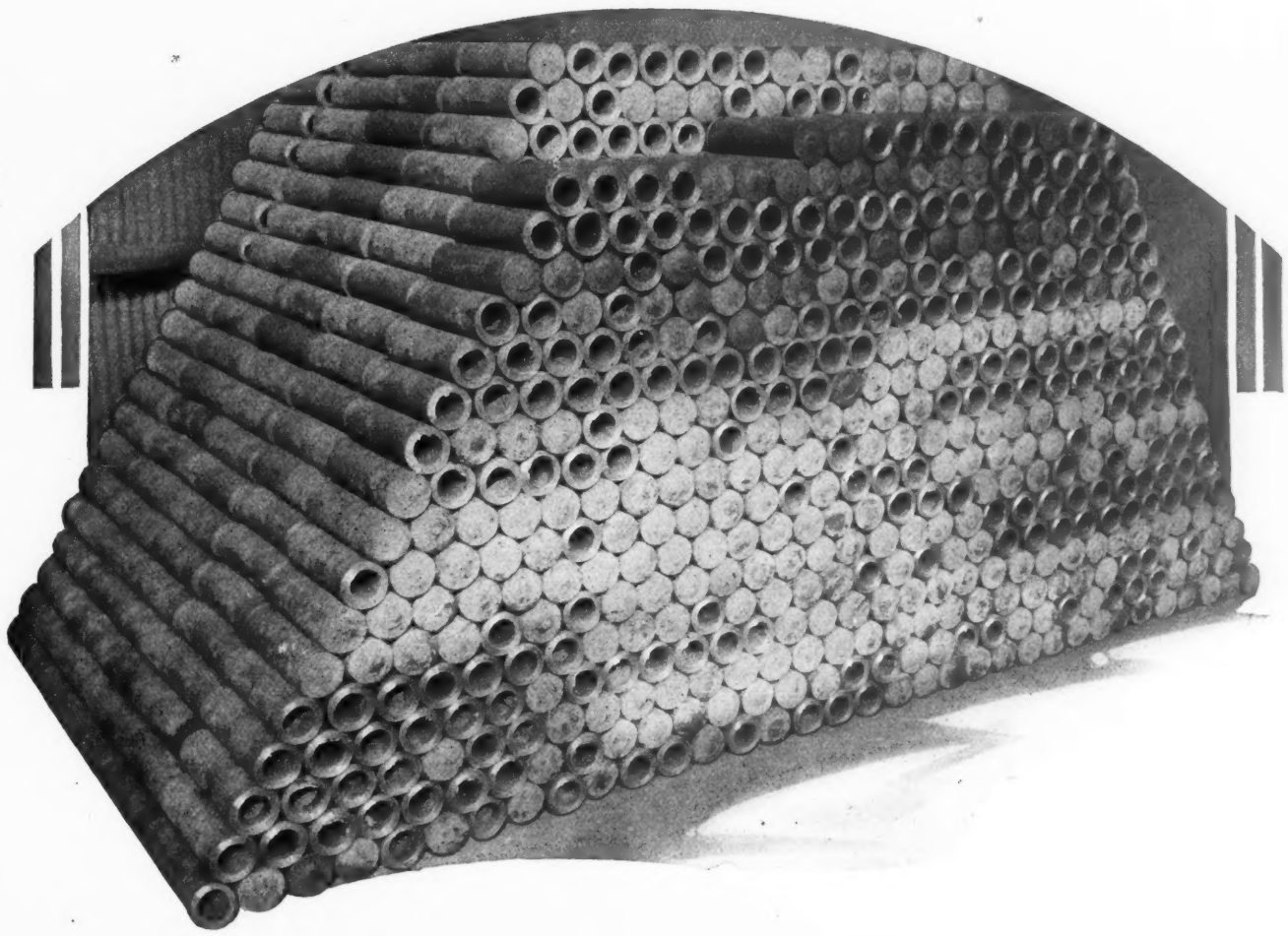


Fig. 26. Diagram illustrating Method of forging Armor-piercing Shells



MACHINING HIGH-EXPLOSIVE SHELLS

A VARIETY of methods are used in machining the British 18-pound (3.29 inch) high-explosive shell shown in Fig. 27. In the greater number of cases, however, the shell is machined from bar stock. There are two principal methods used in machining from bar stock. One of these, outlined in Table I and described in the following, consists in cutting up bars of hot-drawn stock into billet lengths; these are then drilled and reamed, and afterward turned, etc. The other, while similar in the final operations, starts with turning. A bar generally sixteen feet long is centered on both ends, then put in the lathe and turned down to approximately the finished size. After this, it is cut up into shell lengths, drilled, reamed, threaded, etc.

Cutting off 18-pound Shell Blanks

Many different methods are in use for cutting off shell blanks. Usually, however, several blanks are cut off at one time. The Earle Gear & Machine Co. has devised a fixture for the Lea-Simplex cold saw by means of which nine bars can be cut off at one setting. The average cutting time for nine bars is nine minutes, and the production on 3¼-inch bars is about sixty per hour.

Drilling and Reaming

After cutting off, the next operation is rough-drilling. This is usually performed in a high-power drilling machine as shown in Fig. 28. The shell blank is held in a special fixture, shown in Fig. 29. This comprises two jaws, operated by left- and right-hand screws by means of handwheel *A*. The top part of the fixture is of yoke form and carries the drill guiding bushing *B*. In this particular case, the drilling is done with a "Hercules" 1 13/16-inch drill, rotated at 115 R. P. M. and fed down into the work at a feed of 0.017 inch per revolution of the work. The hole drilled is 8⅞ inches deep, and the production nine per hour. To start the drill central with the blank, a bushing is slipped into the top of the jig and when the drill has once started properly this is removed.

The second operation consists in rounding the bottom, that is, removing the vee left by the end of the drill. This is done with a counterboring tool which is rotated at 115 R. P. M. and fed down by hand. The machine used is a Baker high-power drilling machine and the production is thirty per hour. The third operation consists in reaming the hole to 1.885 inch diameter with a reamer rotated at 115 R. P. M. and fed at the rate of 0.032 inch per revolution to 8 15/16 inches deep. The production is twelve per hour.

Turning Band Groove, Waving, etc.

The fourth operation is performed on a No. 2-A Warner & Swasey turret lathe in the order shown by the diagram Fig. 30. This consists first in rough-turning the external diameter with box-tool *A* for a distance of about 6⅜ inches from the base end and removing ¼ inch from the diameter at a feed of 0.041 inch per revolution of the work; second, boring gas plug recess, facing end, turning and forming radius with tool *B;* third, rough-forming band groove with tool *C;* fourth, finish-facing plug recess and end with tool *D;* fifth, forming waves in band groove from cross-slide with tool *F;* sixth, finish-boring, counterboring and chamfering plug recess with tool *G;* seventh, under-cutting band groove with tool *H*. As will be seen the waving is done from the cross-slide, and at the same time the work is supported by a roller support from the turret. For the finishing cuts, the work is rotated at 187 R. P. M., and the production is six and one-half to seven per hour.

The fifth operation consists in rough-turning the nose in a Reed-Prentice 20-inch engine lathe, as shown in Fig. 31, with a single tool operating at a feed of 0.071 inch per revolution, and with the work revolving at 56 R. P. M. The shell is held in a special draw-in collet *A* which is supported by a steadyrest, as shown. Three cuts are required to finish the nose of the shell to form, the tool being controlled in its movement by a cam located at the rear of the machine. The production is twelve to fourteen per hour.

The sixth operation is performed on a No. 2-A Warner & Swasey turret lathe, as shown in Fig. 32. In this set-up the shell is rough-faced to length and the clearance angle cut on the nose. The recess is then cut at the bottom of the thread with recessing tool *A* and the hole reamed for thread-

TABLE I. ORDER OF OPERATIONS, MACHINES AND TOOLS USED, AND PRODUCTION FIGURES ON 18-POUND BRITISH HIGH-EXPLOSIVE SHELLS

Number of Operation	Character of Operation	Machine	Tools	Feed in Inches	Speed, R. P. M.	Production Per Hour
0	Cutting Off Bar Stock (9 Bars)	Earle Gear & Machine Co.	Huther Saw	.....	.....	60
1	Drilling Hole	Baker Drill	"Hercules"	0.017	115	9
2	Rounding Bottom of Hole	Baker Drill	Morrow Mfg. Co.	Hand	115	30
3	Reaming Hole	Baker Drill	Morrow Mfg. Co.	0.032	115	12
4	Turning, Facing, Waving, etc.	2 A Warner & Swasey	Edgar-Allen Steel	0.041	187	6½ to 7
5	Rough-turning Nose	Reed 20-inch Lathe	Edgar-Allen Steel	0.071	56	12 to 14
6	Facing, Turning, Recess, etc.	2 A Warner & Swasey	Edgar-Allen Steel	0.028-0.058	78	15 to 17
7	Finish-turning	Reed 18-inch Lathe	Edgar-Allen Steel	0.047	100	12 to 15
8	C. Bore and Drill Screw Hole	Barnes Drill	.....	.....	.....	40
9	Tapping Screw Hole	Barnes Drill	Peter Bros. Chuck	.....	40	40
10	Face Recess in Base	Fay & Scott 16-inch Lathe	Edgar-Allen Steel	0.031	180	40
11	Threading Nose	Holden-Morgan	.....	.....	.....	20
12	Recessing and Threading Base	Holden-Morgan	.....	.....	.....	13
13	Washing and Inspecting	.....	.....	.....	.....	.....
14	Screwing in Base Plug	Vise	Wrench	.....	.....	30
15	Cutting Off Projection	Jenckes Lathe	Edgar-Allen Steel	Hand	180	32
16	Riveting Gas Plug	High-Speed Hammer	.....	.....	500 Blows	120
17	Facing Base End	Jenckes Lathe	Edgar-Allen Steel	0.031	180	20
18	Cutting Air Grooves in Waves	Brown-Boggs Press	.....	.....	.....	240
19	Pressing on Copper Band	Goldie & McCulloch Press	.....	.....	.....	40
20	Finishing Copper Band	Warner & Swasey Lathe	Edgar-Allen Steel	Hand	120	40
21	Varnishing	Bowser Varnish Machine	.....	.....	.....	120
22	Baking	Crawford Furnace	.....	.....	.....	30
23	Cleaning, Insp. Screw in Plug	.....	.....	.....	.....	.....
24	Stamping	Holden-Morgan Stamping Machine	.....	.....	.....	60
25	Inspecting	.....	Gages, etc.	.....	.....	.....

Machinery

ing to 1.906 inch diameter, 1.2 inch deep, with tool *B*. A light cut is then taken across the radius on the nose with tool *C* which carries a roller pilot and is operated from the cross-slide. The work is rotated at 78 R. P. M. for the profiling or the radius cut at a feed of 0.058 inch per revolution. The feed is reduced to 0.028 inch per revolution for reaming. The production is fifteen to seventeen per hour.

The seventh operation consists in finish-turning from the band groove to the nose on an F. E. Reed 18-inch engine lathe as shown in Fig. 33. Here it will be seen that the cross-feed screw has been removed and the movement of the cross-slide is controlled by a former at the rear. The shell is held at the closed end by a two-jaw chuck, and located by a stop-screw *A*; a plug is screwed into the open end and is supported on the tailstock center. The work is rotated at 100 R. P. M. and the feed is 3/64 inch per revolution. One man runs two machines and the production is twelve to fifteen per hour from each machine. The eighth operation is to counterbore and drill the grub-screw hole *A*, Fig. 27, in the nose of the shell for fastening the fuse in place.

The ninth operation on the shell consists in tapping the screw hole with a Peter Bros. tap chuck held in a Barnes drill. It requires two taps to finish this hole and they are operated at 40 R. P. M. The production is forty per hour. The tenth operation is to face the recess in the cavity in the base end of the shell where the gas plug is to be inserted. This is performed in a Fay & Scott 16-inch engine lathe, and one cut is taken with a tool held in a special holder. The tool is started at the outside of the recess and works in toward the center. The work is rotated at 180 R. P. M. and the feed is 1/32 inch per revolution; the production is forty per hour.

Threading Nose and Base Ends

The eleventh operation consists in threading the nose of the shell. This is performed in a Holden-Morgan thread milling

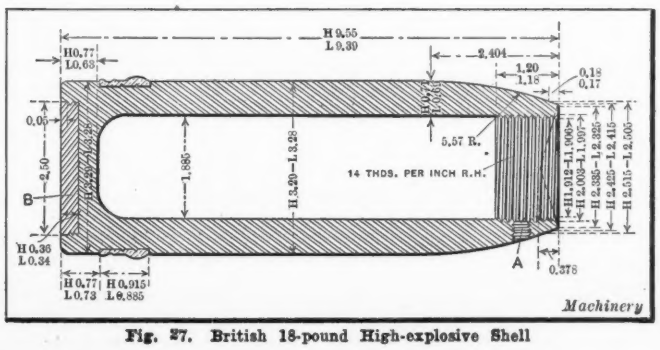


Fig. 27. British 18-pound High-explosive Shell

machine, as shown in Fig. 35. A hob similar in construction to that described in the following in connection with Fig. 34 is used for cutting the thread, and one revolution of the work completes the thread, which requires 1.10 minute. The production is twenty per hour from each machine, one operator attending to two machines. The twelfth operation

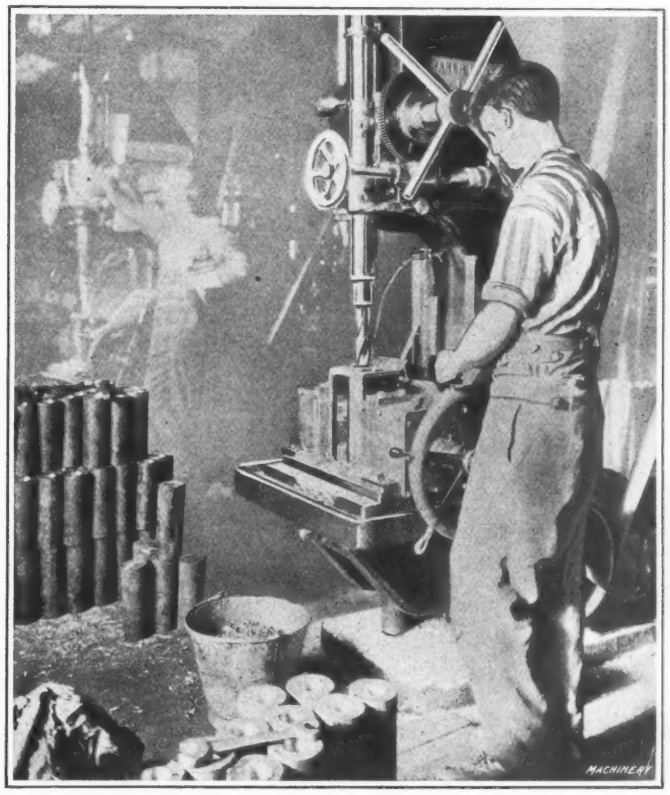


Fig. 28. Baker High-power Drilling Machine at Work on British 18-pound High-explosive Shells

consists in recessing and threading the base end of the shell in a Holden-Morgan threading machine of the same type as those shown in Fig. 35. Here one man also runs two machines, one being set up for recessing and the other for threading. The production is 130 in ten hours from the two machines. The thirteenth operation consists in washing in hot soda water, after which the shells are inspected.

Machining the Gas Plug

Before any other operations are performed on the shell, however, the gas plug is made. The gas plug *B*, Fig. 27, is

made from a forging and is faced, turned and threaded on the Holden-Morgan special plug milling and threading machine shown in Fig. 34. The plug is held by the tail in a special draw-in chuck. The first operation is to rough-turn and face the end of the plug, two cuts being taken. The tools used are located one behind the other in tool-holder *A* that is fastened to the front of the cross-slide operated by handwheel *B*. On the rear of the same slide is a special holder *C* that carries the threading tool. This consists of a hob built up of a series of concentric disks provided with cutting teeth and held on a special arbor that is driven by a separate belt *D*. To cut the

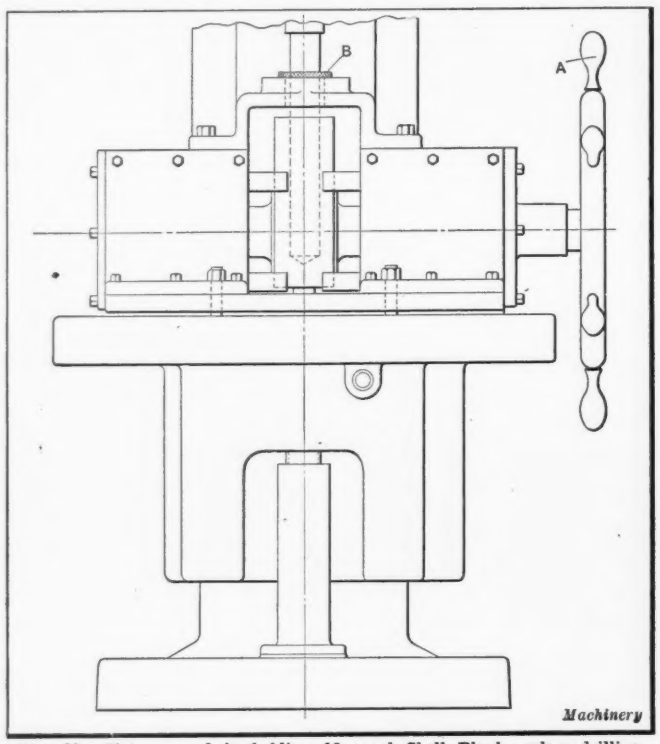


Fig. 29. Fixture used in holding 18-pound Shell Blanks when drilling

thread, lever *E* is pulled down, withdrawing a stop which allows the spindle to "feed" back into the housing. The spindle driving mechanism is then shifted to slow speed, and the spindle moves back at the required pitch—slightly over one complete revolution of the work (which takes forty seconds) finishing the thread. The work is rotated at 200 R. P. M. for turning and facing, and the production is twenty per hour.

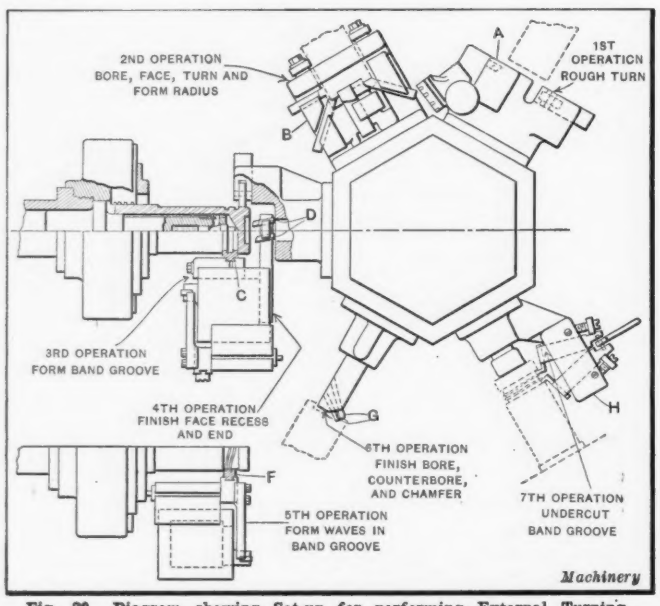


Fig. 30. Diagram showing Set-up for performing External Turning, Facing and Waving Operations

Final Machining, Stamping, Varnishing and Inspecting

The fourteenth operation consists in screwing in the base plug, which is first coated with red lead. Two men are employed for this operation, one inserting the plug and the other screwing it in with a wrench. The production is thirty per hour. The fifteenth operation consists in hogging off the

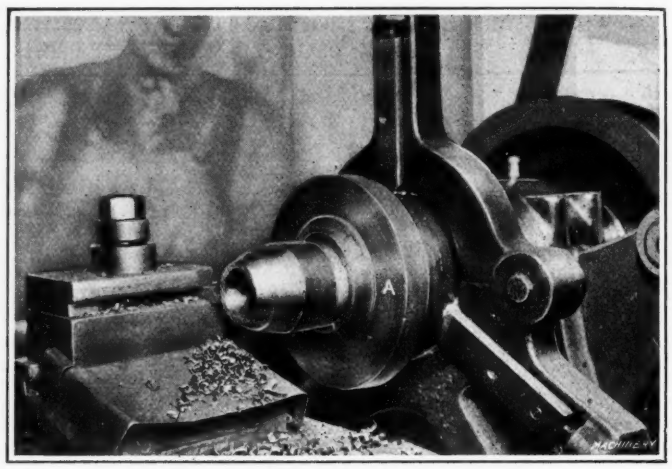


Fig. 31. Rough-turning Nose in an Engine Lathe

projection on the base plug in a Jenckes lathe. First, a facing cut is taken along the plug, then the teat is cut off and finally a finishing cut is taken. The production is thirty-two per hour, and the lathe is operated at 180 R. P. M., hand feed being used.

The sixteenth operation consists in riveting in the gas plug with a "High-Speed" hammer operating at 500 blows per minute, as shown in Fig. 36. The shell is held on an arbor

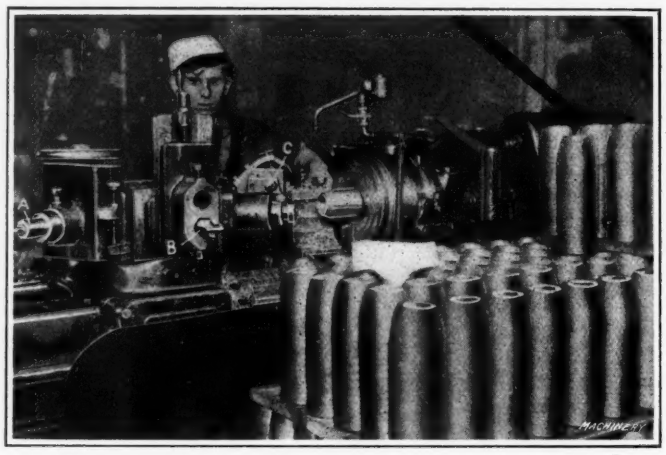


Fig. 32. Performing Sixth Operation on a 2-A Warner & Swasey Turret Lathe

and is spun around by the operator as the hammer descends. The production is 120 per hour. The seventeenth operation consists in facing the base in a Jenckes machine, one cut being taken at a spindle speed of 180 R. P. M. and 1/32 inch feed per revolution of the work. The depth of cut is 3/32 inch. The eighteenth operation is cutting the air grooves in the waves in the band groove. This is accomplished in a Brown-Boggs inclinable press which carries a fixture in which the shell is located. The cuts are made with a punch, shaped like a cold-chisel, held in the ram of the press, and the production is 240 per hour. In the nineteenth operation the copper band is pressed into the band groove in a Goldie &

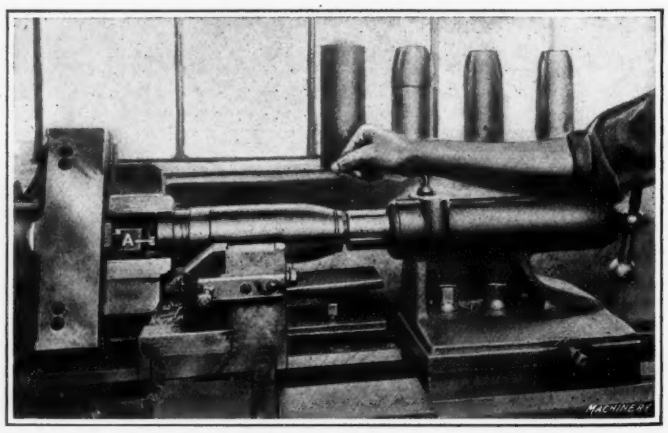


Fig. 33. Finish-turning External Diameter on an Engine Lathe

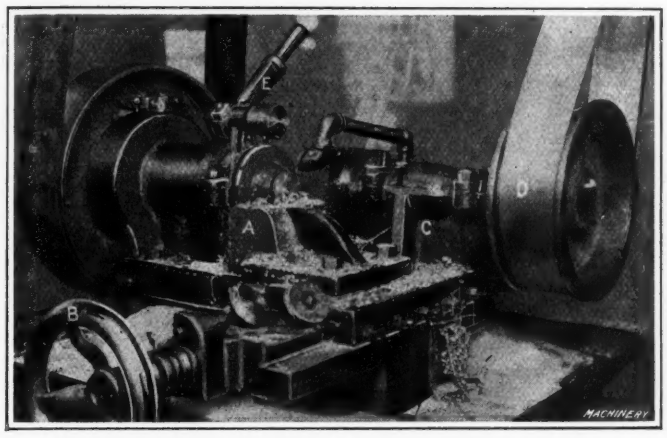


Fig. 34. Machining Gas Plugs on Holden-Morgan Special Plug Machine

McCulloch hydraulic press of the six-cylinder type. Three squeezes are required to compress this band and the production is forty per hour.

For the twentieth operation the shell is brought back to a Warner & Swasey brass working lathe, where the copper band is turned to shape. The work is rotated at 120 R. P. M. and roughing and finishing cuts are taken. The roughing cut is

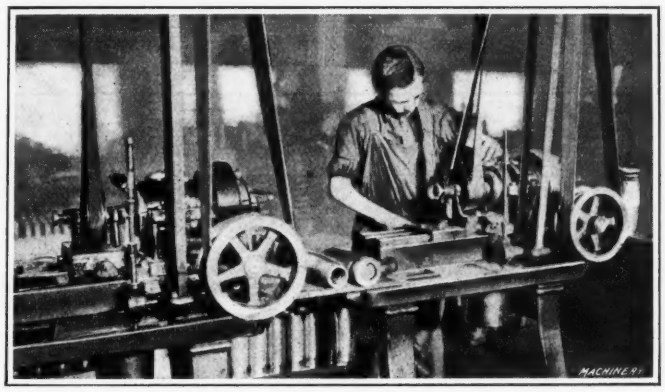


Fig. 35. Threading Nose and Base Ends of Shell in Holden-Morgan Special Thread Milling Machines

taken from the front slide and the finishing cut from the rear. The shell is supported by means of a steadyrest. The production is forty per hour.

The twenty-first operation is varnishing with a Bowser siphon tank, as illustrated in Fig. 37. The varnish is poured

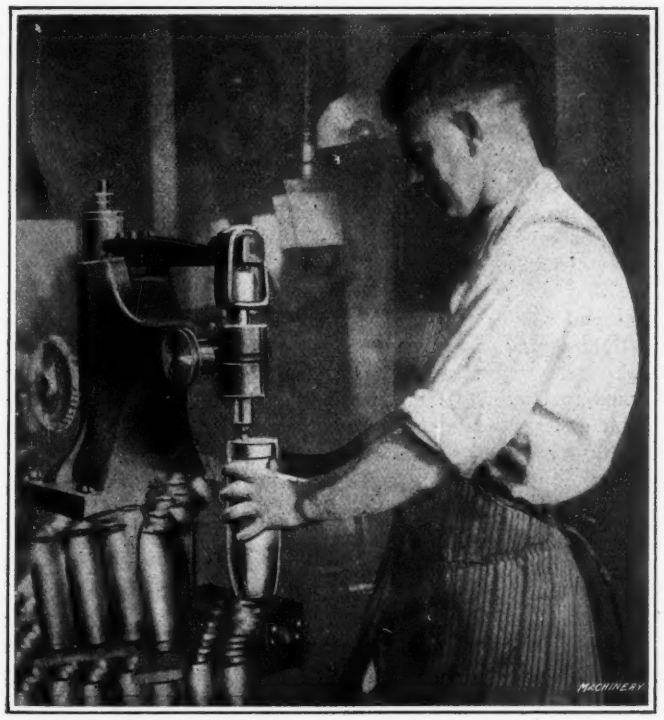


Fig. 36. Riveting in the Gas Plug in a "High-Speed" Hammer

into the shell until it is full; then the shell is turned upside down and the varnish allowed to drain out. The number of pieces varnished per hour is 120. The twenty-second operation is baking in a Crawford sectional furnace which is built by the Oven Equipment Co., New Haven, Conn. Two hundred and forty shells are placed in this furnace, which is heated to a temperature of 300 degrees F. and kept at that temperature for eight hours. The shells are allowed to remain in the furnace for this time and then are taken out and allowed to cool off in the air. The twenty-third operation

Fig. 37. Varnishing Interior of High-explosive Shells

is cleaning the nose of the shell with a rag and gasoline. The shells are then ready for inspection, after which the plug is screwed into the nose end.

The twenty-fourth operation consists in stamping in the

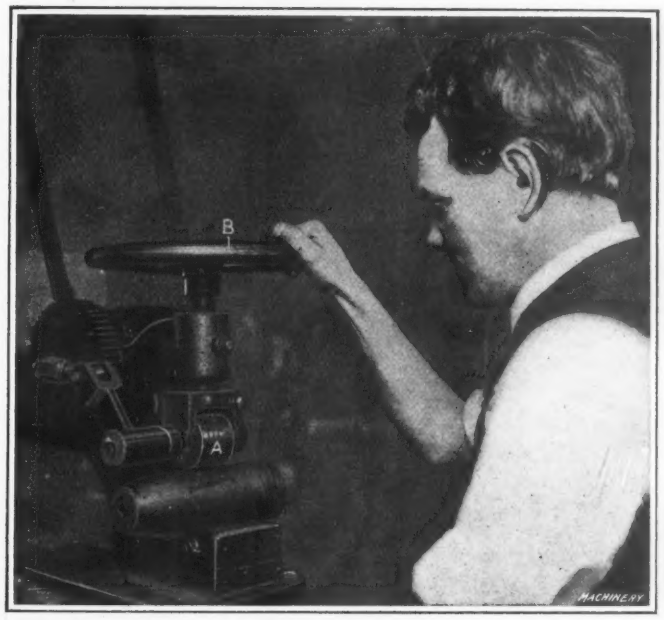


Fig. 38. Stamping in a Holden-Morgan Rotary Stamping Machine

Holden-Morgan machine shown in Fig. 38. The stamp *A* is oscillated by an eccentric and crank movement, and when the stamp is brought down in contact with the work by operating handwheel *B* the shell is rotated by it. The production in this operation is sixty per hour. The twenty-fifth operation is the final manufacturing and government inspection. 240 completed shells represents eight hours' work in this plant.

ANOTHER METHOD OF MACHINING 18-POUND BRITISH HIGH-EXPLOSIVE SHELLS

Another method which is not as widely practiced as that just described is outlined in Table II and in the following. Hot-drawn steel bars 3½ inches in diameter by 16 feet in length are centered in both ends, by first scribing two diametral lines across the ends of the bar and then drilling the center holes with a portable drill. The bars are next set up on centers on an engine lathe and straightened with a jack until they run fairly true. The next step is to turn down one end of the bar to the required diameter for a length of approximately 18 inches; the purpose of this is to form a bearing for the steadyrest which is used during the turning operation and also to provide a starting point for the special turning head employed. The bars are turned down to a diameter of 3.285 inches ± 0.005 inch, and for this purpose a special traveling head, as shown in Fig. 39, is employed. This head carries five tools, three next to the chuck and two on the opposite side of the supporting bushing. The first two cutters are progressive roughing cutters, the third is a "smoothing" cutter, and the two cutters on the right-hand side of the supporting bushing take finishing cuts; the depth of the cut taken by the last finishing tool is very light. Accuracy for diameter is determined by a snap gage and a ring gage; the snap gage is used to make sure that the bar is not turned under size, whereas the ring gage follows along the bar after the turning head. Should it happen that the last tool is cutting too large, the operator takes a file and touches the high spots until the ring gage will pass.

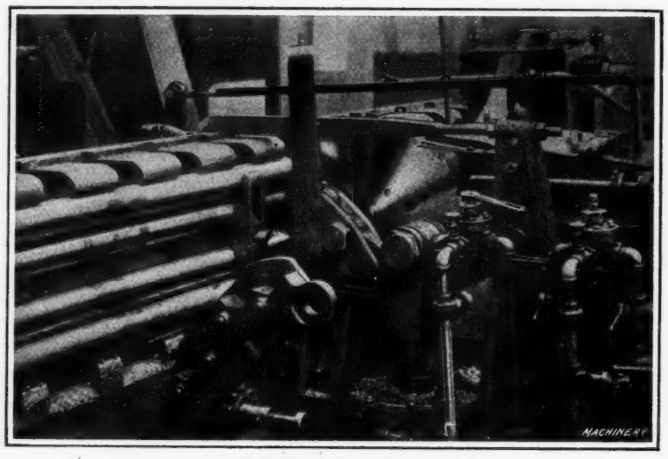


Fig. 40. Cutting Turned Bars to Shell Lengths in a Newton Cold Sawing Machine

TABLE II. PRINCIPAL OPERATIONS ON 18-POUND BRITISH HIGH-EXPLOSIVE SHELLS WHEN MADE FROM TURNED BARS OF STOCK

Number of Operation	Character of Operation	Machines	Tools	Feed in Inches	Speed, R.P.M.	Production Per Hour
1	Sawing to Shell Lengths	Newton Cold Saw	Huther Saw	.....	.....	25
2	Drill, Ream and Form	Barnes 22-inch Drill	Oil-tube Tools	0.013 to 0.093	37 to 145	3
3	Drilling and Tapping for Fixing Screw	Two-spindle Drilling Mach.	Errington Tap-Chuck	.....	.....	48
4	Mill Threads in Nose	Lees-Bradner Thread Miller	Special Hob	.....	.....	35
5	Drill Center in Base	Engine Lathe	Center Drill	.....	.....	50
6	Waving and Under-cutting	Engine Lathe	Form Tools	.....	.....	15
7	Weigh, Mark for Cut-off and Heat No.	Weighing Scale and Chart	Blue Chalk	.....	.....	40
8	Face, Bore and Under-cut Base End	Engine Lathe	Turning Tools	.....	.....	8
9	Thread Base End	Lees-Bradner Thread Miller	Special Hob	.....	.....	40
10	Screw in Gas Plug	Drilling Machine	"Flywheel Chuck"	.....	.....	50
11	Face off Gas Plug and Roll	Engine Lathe	Turning Tools	.....	.....	14
12	Press on Copper Band	West Tire Setter Co. Press	Steel Press Plungers	.....	.....	45
13	Form Copper Band	Engine Lathe	Form Tools	Hand	.....	..
14	Mark	Noble & Westbrook	Lettering Dies	.....	.....	..
15	Varnish Cavity	Special Fixture	Round Brush	.....	.....	..
16	Final Inspection	.....	Special Gages	.....	.....	..

Machinery

Sawing the Turned Bars to Billet Lengths

Two Newton machines equipped with Huther inserted-tooth saw blades are used for cutting up the turned bars into shell blanks 9⅝ inches in length. These machines, as shown in Fig. 40, hold four bars at a time, and are equipped with traversing work-holding fixtures which move the stock along after each successive cut has been completed, a stop being employed to control the length of the blanks. The work is held in the fixture by a special arrangement of clamps which are operated by compressed air cylinders working in conjunction with toggle joints. In order to facilitate loading the bars into the work-holding fixture, an auxiliary rack is provided in which four bars are placed before the four bars in the work-holding fixture have been completed. When the final blanks have been cut from the bars, the work-holding fixture is moved back to the starting point and the auxiliary rack—which is pivoted to the base that supports the traveling work-holding fixture—is swung up by means of a crane hoist. This brings the next four bars into position in the rack ready to be clamped.

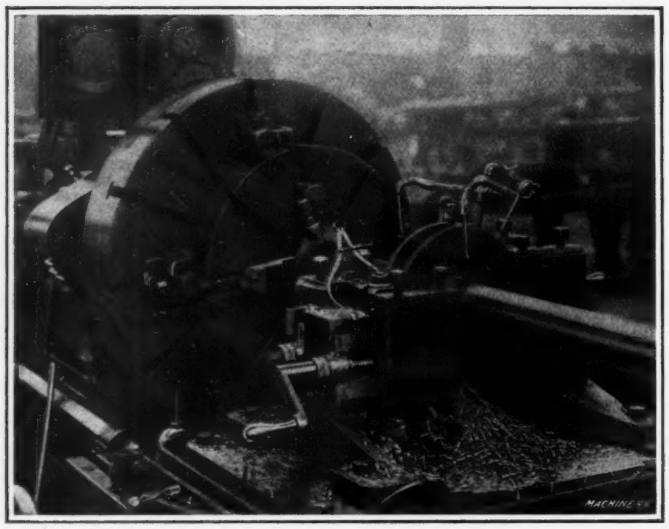


Fig. 39. Turning Long Bars from which Billets for High-explosive Shells are subsequently cut

The design of the traveling work-holding fixture is such that the bars cannot be completely cut up into blanks, the crop end of each bar having sufficient material for three shell blanks. These crop ends are cut up on another cold saw; one of the blanks produced in this way is already turned to size, while the other two blanks are cut from the rough end of the bar which was not reached by the special turning head shown in Fig. 39. These two rough crop ends are turned down to the required diameter on an engine lathe.

Drilling, Reaming and Turning Nose

The method used in this case for drilling, reaming and forming the nose of the shell is of considerable interest. In the first place, the development of fixtures for performing this work on the upright drilling machine is unusual, and in the second place this method has largely overcome the great difficulty experienced in securing early deliveries on all forms

of lathes for machining shells. The inverted tool method of handling this work is commendable in that chip trouble is largely overcome. The equipment used consists of a battery of eight self-oiling 22-inch all-geared drilling and tapping machines built by the Barnes Drill Co., and much of the credit for the development of this method of machining shells is due to the designers employed by this concern. Figs. 41 and 42 show one of these machines equipped for shell work, and reference to these illustrations will show that the shell to be machined is held by a chuck on the drill spindle, whereas the tools which perform the drilling, reaming and nose-forming operations, are carried by a rotary fixture *B* supported on the table of the machine. The fixture consists of a base-plate and rotating table upon which the tool-holders are mounted. The proper indexing of the various tools is provided for by means of a taper pin in the base of the fixture engaging corresponding holes in the rotating table which is rigidly retained by a clamp. The sequence of operations is as follows:

First Operation:—Spot-drill and rough-form nose with tools held in holder *C*. For this operation the spindle rotates at 92 R. P. M. with a down feed of 0.013 inch per revolution. The drilling is done by a short twist drill, and the rough-forming of the nose by three turning tools which are stepped in so that they cut to different depths, leaving an irregular surface which is finished in a subsequent operation. It will also be noticed that the shell is supported by a bronze-lined bushing so the work is adequately supported while being machined.

Second Operation:—Drill hole in shell to required depth with a drill *D* 1 13/16 inch in diameter. For this operation the spindle is rotated at 145 R. P. M. and at a feed of 0.013 inch per revolution.

Third Operation:—Rough-ream the hole with reamer *E*

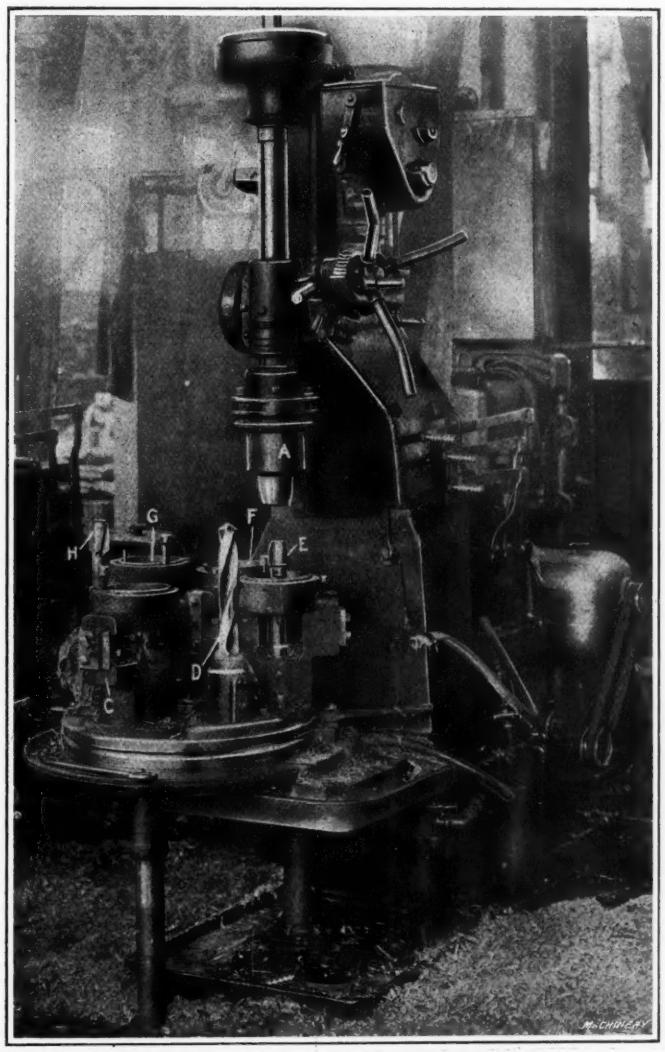


Fig. 41. Machining Hole and Nose of Shell Blank in Barnes Drilling Machine

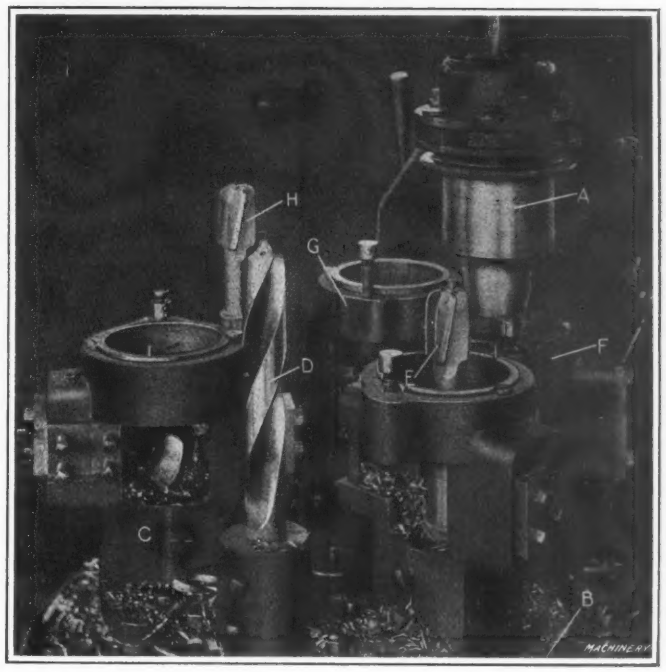


Fig. 42. Close View of Fixture shown in Fig. 41, illustrating Method of applying Tools to Work in an Inverted Position

which is formed at the end to finish the bottom of the cavity to the required shape. For reaming, the spindle is operated at 37 R. P. M. with a down feed of 0.093 inch per revolution. When the reamer reaches the pointed end of the hole as left by the twist drill, the power feed is disengaged and the spindle fed down by hand until the positive stop is reached.

Fourth Operation:—Finish-form nose with form-cutter located in holder *F*, which is bronze lined. The spindle is rotated at 45 R. P. M. and fed down by hand.

Fifth Operation:—Cut step and bevel on nose of shell. The work is supported by a bronze-lined tool-holder *G*, and the machine is operated at the same speed and feed as for the fourth operation. The bevel on the inside of the nose is machined by a double-ended cutter of the proper form, which is supported at the center by a toolpost bolted to the base of the fixture. The step is formed by two forming tools carried by toolposts bolted to the base of the fixture.

Sixth Operation:—Finish-ream with reamer *H*. This operation must be performed with great care, as the specifications require that when an electric light be dropped into the hole the surface will show a uniform polish in all places. This operation is performed with the spindle rotating at 37 R. P. M. with a down feed of 0.093 inch per revolution.

By holding the shell in a fixture on the drill spindle, advantage is taken of the inverted principle which allows the chips to clear themselves more freely than would otherwise be the case. All the drilling and reaming tools used are of the oil-tube type and are supplied with forced lubrication. The chuck in which the work is held is arranged with three serrated eccentric jaws mounted on a rotating ring. To clamp the work in the chuck, the ring which carries the jaws is turned back against spring tension to allow the work to be pushed up into place. The ring is then released and snaps back to give the jaws a preliminary grip on the shell. When the machining operation is commenced the resistance of the work to the cutting action of the tools causes a further rotation of the ring on which the chuck jaws are carried, with the result that the jaws rock in on their eccentric pivots to secure a firmer grip on the work. After the machining operations have been completed, the work is removed from the chuck by a wrench which is slipped over the end of one of the jaws, and pressure is applied to rotate the chuck ring in the opposite direction from that necessary to tighten the jaws.

Drilling and Tapping for the Fixing Screw

The next operation is drilling and tapping the hole in the nose for the fuse fixing screw. This is accomplished in a

two-spindle drilling machine as shown in Fig. 43. The first spindle is used for counterboring and drilling. After the hole has been started with drill *A* it is removed and the smaller drill *B* inserted. The fixture carrying the work is now moved over to the second spindle of the machine and the hole threaded with tap *C*, which is held in an Errington chuck. For this operation, of course, it is necessary to remove the drill guide bushing.

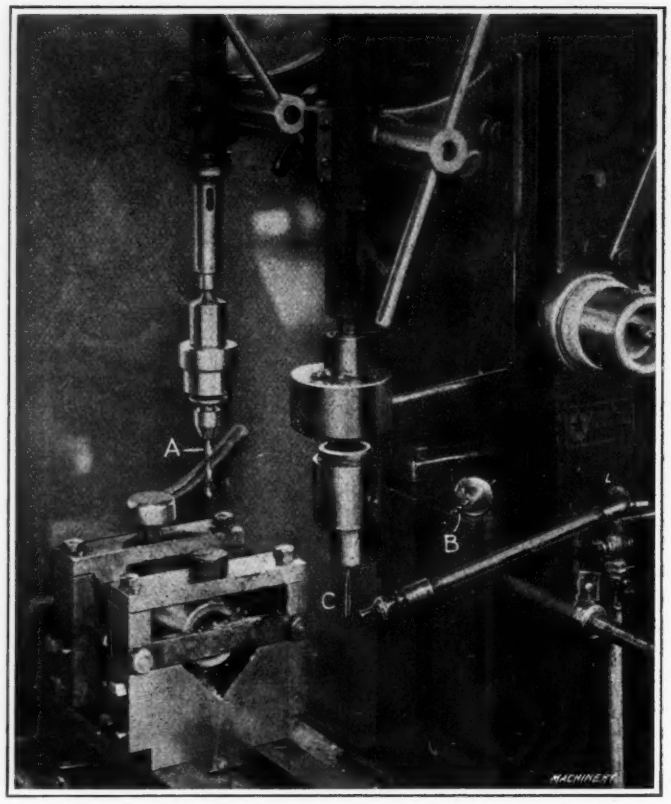


Fig. 43. Drilling and tapping Hole for Fuse Fixing Screw

Milling the Threads in the Nose

The shells are now taken to the special Lees-Bradner thread milling machine shown in Fig. 44. For this operation the shell is held in an air chuck with the open end out. The threading is done with a multiple type cutter *A*, of a length sufficient to completely cover the length of the part to be threaded and which is rotated by a separate belt *B*. The cutter-slide is fed toward the head of the machine, and the work rotated at the same time so as to cut a thread of the correct pitch. This is controlled through a change-gear system located at the left-hand end of the machine.

Turning, Under-cutting and Waving Band Groove

The machining of the band groove is the next important operation, but before this is accomplished a center hole in the base end of the shell is drilled. After this operation, the shells go to the preliminary inspection department where the thread in the nose is tested with a thread plug gage. A driving center is then screwed into the nose of the shells, and they are returned to the machining department. The band groove is machined as shown in Fig. 45. The roughing out of the band groove is done by means of a formed tool held on the rear cross-slide, which leaves sufficient stock to form the waves. The next step is to under-cut the sides of the band groove, and this is accomplished by two tools held in the holder *B*. When one tool is in action, the other clears the end of the shell. The machining of the waves is performed by tool *C* held in holder *D*. This holder forms part of a slide which carries a roller that engages with cam *E*. Spring *F* keeps the roll in contact with the cam, so that when the latter rotates an oscillating movement is imparted to holder *D*.

Preliminary Inspection and Machining Gas Plug Seat

After the band seats have been machined, the driving centers are removed from the nose of the shells and the latter are subjected to a preliminary inspection. This consists in weighing in order to determine the amount of stock which must be removed from the base to bring the shells to standard weight. The normal weight of the finished shell is 14 pounds, 13.15 ounces, and a tolerance of 1 ounce is allowed. Experiments have established the fact that each ounce of weight on the shell is equivalent to 0.026 inch in length at the base, so that by removing metal on this basis the weight of the shell may be reduced to normal. The inspector who weighs the shells has a chart before him on which the various weights of shells are typewritten, together with the corresponding amount of metal in thousandths inch which must be removed from the base in order to bring the shell to normal weight. At this stage the shells also have the heat number of the steel bar stamped on the base, and as the metal is to be removed from the base the inspector transfers this heat number to the side of the shell. After he has weighed the shell and determined the amount of metal that must be removed, he marks the number of thousandths inch to be removed on the side of the shell with blue chalk, and the shells are then sent on to the lathe department where the correction for weight is made while the hole is being bored to receive the gas plug.

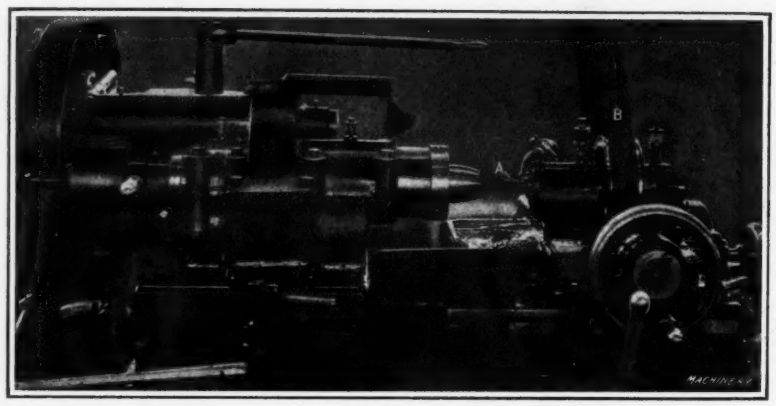


Fig. 44. Milling Threads in Nose in a Special Lees-Bradner Thread Milling Machine

The engine lathe used for facing the base end is equipped with a special micrometer attachment which enables quick settings to be made. This attachment, as shown in Fig. 46, consists of a bracket bolted to the lathe bed, on which the spindle of a micrometer *A* is supported. The connection between the micrometer and the supporting bracket is cushioned by means of a spring, so that when the lathe carriage is brought up against the micrometer spindle, the spring will take up the strain and prevent the instrument from being damaged.

In operation, the shell is gripped in a Hannifin air chuck and the facing tool brought into contact with the base of the shell. The micrometer spindle is then screwed up against the end of the lathe carriage and a reading taken, after which the spindle is backed away the necessary number of thousandths inch which the inspector has found must be removed from the shell to bring it to normal weight. The carriage is now moved out until the tool clears the work, then moved to the left until it contacts with the micrometer spindle. After this setting, the cross-slide is fed in until the tool passes beyond the circumference of the hole subsequently to be bored. The cross-slide is then backed away from the work and the boring tool *B* held in the tailstock spindle is fed in to bore the hole for the plug. The turret toolpost is then revolved to bring the reaming tool into position to take a finish cut on the side and bottom of the hole. The tool used for this purpose has a double cutting edge with the edges located at right angles to each other. After the finish cut has been taken, the turret toolpost is again rotated to bring the under-cutting tool into the working position, and the under-cut is made.

The shells now go to another Lees-Bradner thread milling machine of the type shown in Fig. 44, where the threads for the gas plugs are milled. These plugs are drop-forgings provided with a triangular

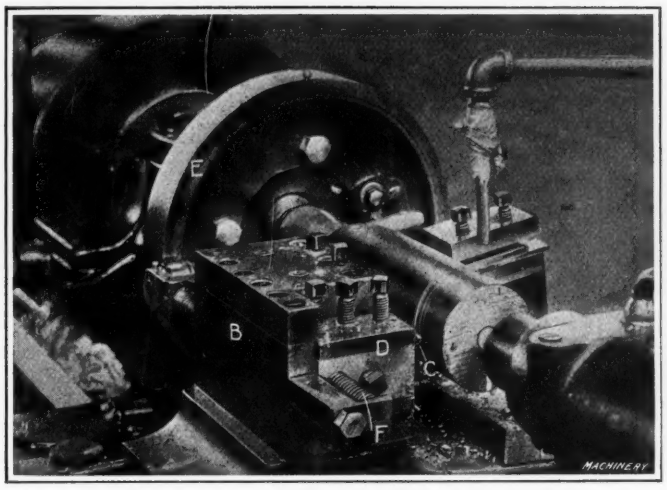


Fig. 45. Turning, under-cutting and waving Rifling Band Groove

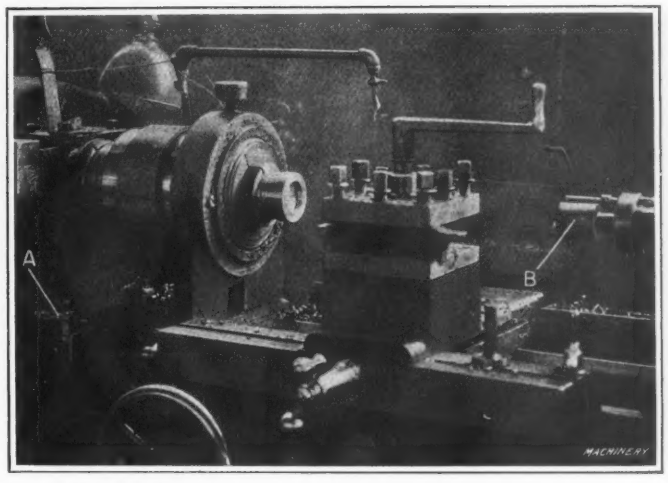


Fig. 46. Facing-off Base End and machining Gas Plug Seat

head to fit the wrench used in screwing them into the shells. Before being screwed into place, the disks are painted with red lead on the bottom and threads and screwed loosely into the shells. The work then goes to an upright drilling machine, Fig. 47, equipped with a special fixture for use in driving the gas plugs down firmly into the shells. The machine spindle, as will be seen, carries a heavy flywheel *A* to give the necessary momentum. The fixture *B* in which the work is held is pivoted on the table of the drilling machine so that it may be swung out of the way of the flywheel for setting up the work and removing the shell after the plug has been driven home, a stop being provided for locating the work under the spindle. The end of the spindle is fitted with a wrench which engages the triangular nut on the disk when the spindle is fed down. When engagement is made in this way the momentum of the flywheel drives the disk home with sufficient force to screw it firmly into place, after which the continued motion of the spindle results in twisting the corners off the nut.

It is now necessary to remove the projection from the base of the gas plug, and face off the base of the plug. For this purpose the shells are taken to an engine lathe equipped with a Hannifin air chuck and a turret toolpost. The projection is removed by a roughing tool, after which the turret head is revolved to bring a finishing tool into position to take a light cut across the entire base of the shell. The turret head is again rotated to bring a third tool carrying a hardened tool steel roller into position. This roller is used to spin over the slight seam between the plug and cavity in the shell. The result is that any slight burr which was raised at the joint during the turning operation is rolled down, making the joint so smooth as hardly to be seen.

Pressing and Forming the Copper Band

The shells now to go to a West Tire Setter Co. banding press, where the copper band is pressed into the groove. After this has been done the shells are passed on to an engine lathe equipped with a Hannifin air chuck and formed tools for forming the bands. Two forming tools are used for this purpose, the roughing tool being a radial tool carried at the front of the fixture bolted to the cross-slide, whereas the finishing tool is of the tangential type and is located at the back of the fixture. The shells are then taken to a Dwight Slate stamping machine, where they are marked. They are then washed in hot soda water to remove the grease, after which they receive a final washing in alcohol to remove all traces of soda. As the shells come from the alcohol bath they are taken out and placed on an inclined table, on which they roll down until they come into contact with an accumulation of shells at the base. These shells are in a convenient position for the man who performs the painting operation on the inside. The device used for this purpose consists of two rollers which are normally located beneath the surface of the bench. When the operator is ready to paint a shell, he takes it from the bench and places it in position over the hole through which the rollers are raised by depressing a foot-treadle. The result is that the shell is held between two rollers which impart a rotary motion to it. The painter then takes a round brush of suitable size, dips it into the shellac pot and pushes it into the shell. An experienced painter can varnish shells very rapidly by this method.

After the varnish in the shells has dried, they are inspected. The production is 1000 per day of twenty-three hours. Eight shells from each day's production are sent to the proving grounds for test, and as soon as a favorable report has been obtained, the shells are shipped to the loading factory.

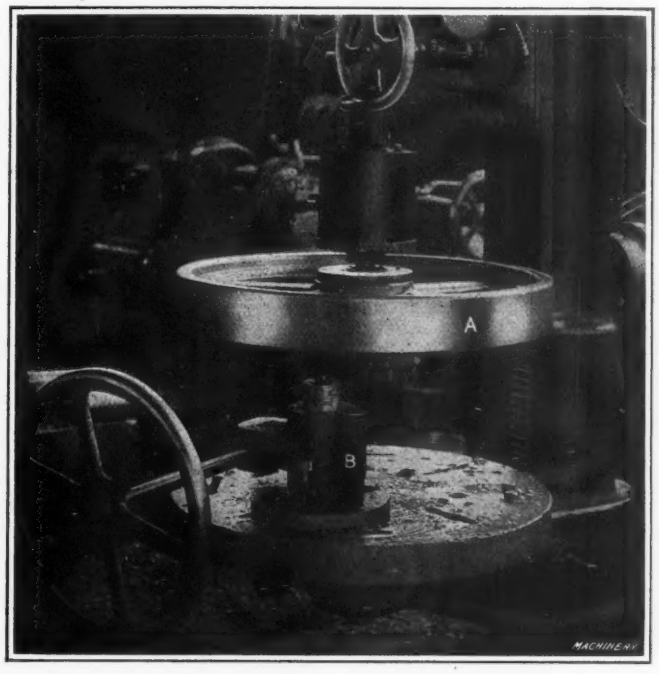


Fig. 47. Fixture used for driving in Gas Plugs

MACHINING RUSSIAN 3-INCH HIGH-EXPLOSIVE SHELLS

Following the forging of the Russian 3-inch high-explosive shell, Fig. 48, as previously described the first machining operation is cutting off the open end. This is done in a Curtis & Curtis shell cutting-off machine as shown in Fig. 49. The forging is located by means of the gage shown at the front of the machine, and the cutter-head, carrying four radial cutters, is rotated about the stationary shell. The cutters are automatically fed into the work and at the end of the cut are returned to the starting point. The cutting is done at a work speed of 65 surface feet per minute, and a lubricant called "Cut-cool" is used for cooling and lubricating the work. The wall of the shell is about ½ inch thick, and the cutting off is done at the rate of fifty shells per hour. On an average, 100 shells are cut off before the cutters require grinding. The base end is now cen-

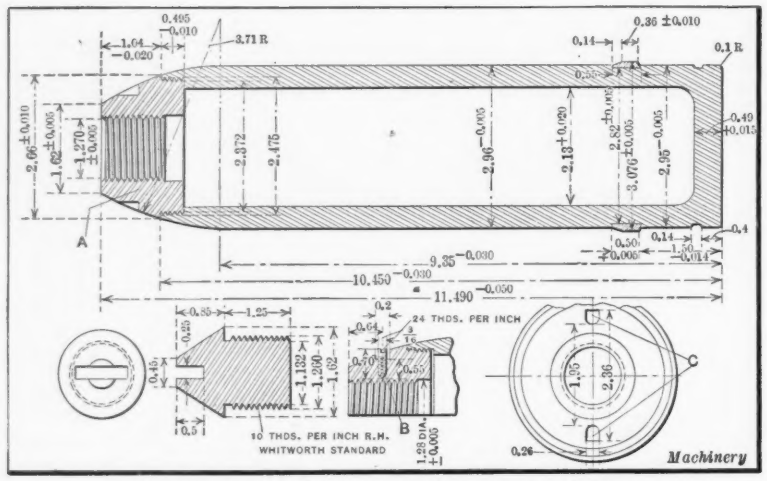


Fig. 48. Russian 3-inch High-explosive Shell and Plug

tered in a Rockford drilling machine provided with a special arbor mounted on the table over which the shell is slipped. After being centrally located, the shell is drilled and countersunk with a combination center reamer.

Heat-treating Russian High-explosive Shells

It is the practice of one plant to heat-treat the Russian high-explosive shell before any of the important machining operations are performed—in fact, it is heat-treated after the centering operation just described. Fig. 50 shows the furnace used for heating the shell previous to quenching; this is designed and built by the Laconia Car Co., and is shown

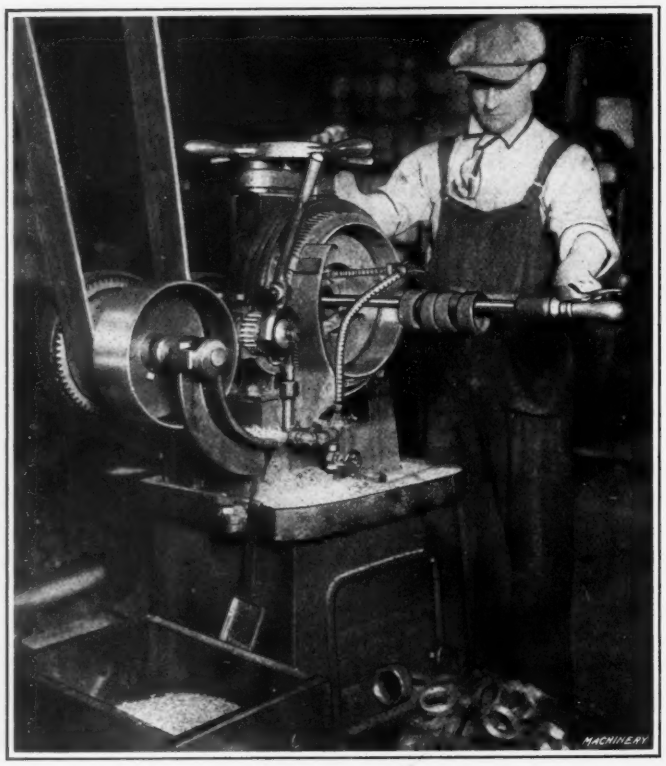


Fig. 49. Cutting off Open End of Shell Forging

in detail in Fig. 21. The shells are loaded into the furnace seven at a time by a special fork mounted on wheels, as shown in Fig. 50. The furnace holds thirty-five shells, and it requires thirty-five minutes to heat one lot of shells to the desired temperature—1470 degrees F. In removing the shells from the furnace, the fork is rolled under a layer of seven shells, which are pulled out, and the shells are gripped by a pair of tongs, and quickly immersed in a bath of running water. They are placed on racks at the bottom of the bath and allowed to get thoroughly cool before removing.

The tempering is done in lead baths, also designed and built by the Laconia Car Co. These are 34 inches wide, 34 inches high by 4 feet 9 inches long. The lead pot proper is of cast iron with one-inch walls, and measures 12½ by 14 by 24¾ inches. It is surrounded by a 1¼-inch fire-brick lining. One burner is used to heat the lead bath to 1100 degrees F. This one burner consumes 4½ gallons of fuel oil per hour. The shells are completely submerged in the bath for seven minutes, then taken out and allowed to cool slowly in the sand. To keep the shells below the surface of the lead bath, they are suspended on pins held on a crank, which is turned to force the shells down or bring them up as required. Five men, with the aid of three muffle furnaces and two lead pots, can heat-treat 100 shells per hour.

Rough-turning External Diameter

Following heat-treating, the next operation is rough-turning; this is accomplished in a 16-inch lathe, as shown in Fig. 51. The shell *A* is supported at the closed end on the lathe center, and is supported and driven from the open end, on the taper mandrel

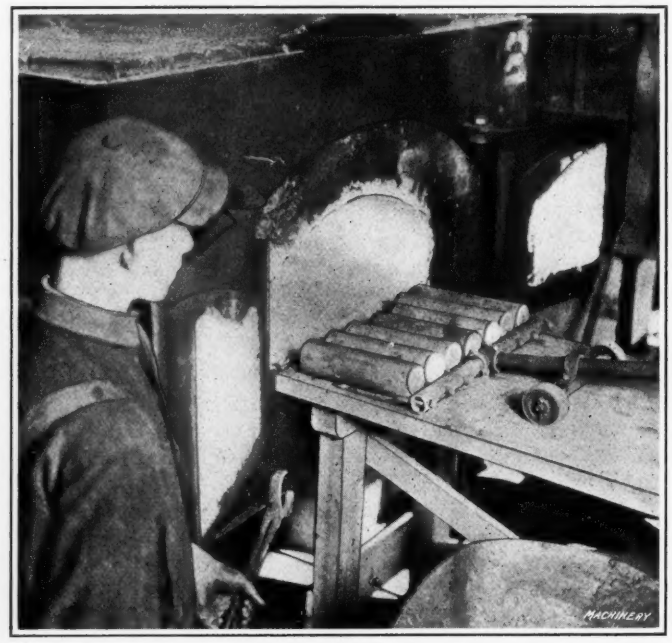


Fig. 50. Heating Russian High-explosive Shell Forgings for Hardening

B. This resembles a reamer in shape, but, of course, is not provided with cutting edges. A single cutting tool is used and the depth of the cut varies from 3/16 to ¼ inch on the diameter. The work is rotated at a surface speed of from 60 to 70 feet per minute, and the feed is 1/16 inch per revolution.

Machining Interior of Russian High-explosive Shell

The boring, counterboring and reaming operations on the interior of the Russian high-explosive shell are performed on a turret lathe, as shown in Fig. 52. The order of operations is as follows: First, bore mouth of shell with boring tool *A;* second, rough-drill entire length of shell with tool *B;* third,

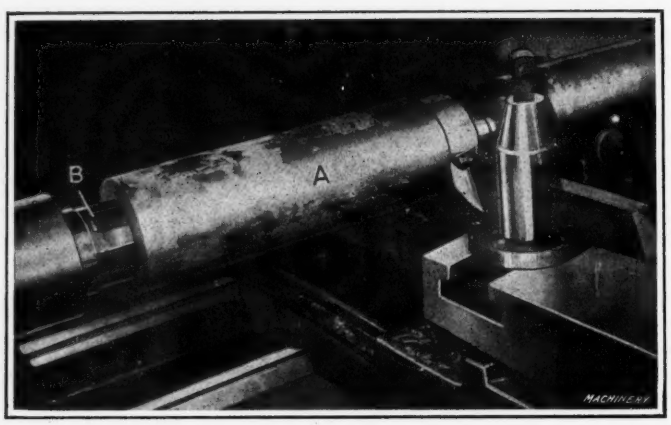


Fig. 51. Rough-turning External Diameter

finish-drill with tool *C;* fourth, finish bottom of shell with tool *D;* fifth, finish-ream entire length of shell with tool *E;* and sixth, counterbore with tool *F*.

Following the operations on the inside, the shell is held in a three-jaw chuck on a Davis lathe, and the solid end is rough-faced. After this, the shell is again chucked and the mouth is recessed preparatory to threading. Following this, the shell is held in a four-jaw chuck, as shown in Fig. 53, the outer end being supported by a steadyrest. The operations performed at this setting consist in roughing out the thread with tool *A*, taking a light cut across the end with tool *B* and finishing the thread with tap *C*.

Final Turning, Facing and Banding Operations

The base end of the shell is now finish-faced, the corners rounded slightly, and the band groove cut. The next step is to machine the under-cut in the band groove, which is performed by means of a special fixture. After this, the adapter or nose is fitted into the end of the shell, and the end of the shell is machined to shape. This operation is performed by inserting a nose plug that is used as a center as shown in Fig. 54. The radius turning is done by means of a former-

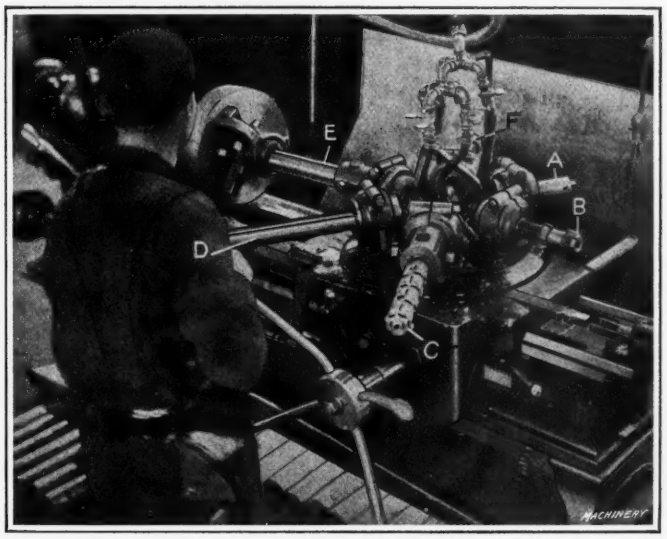


Fig. 52. Boring, counterboring and reaming Cavity of Russian High-explosive Shell

plate *A*, against which the roll *B* held on the carriage is pulled by a heavy weight attached to chain *C*. Grinding of the body of the shell is now performed on a plain grinding machine, in which the three-operation method is employed. This is followed by pressing on the band which is done in a West Tire Setter Co. shell banding press. The rifling band is now formed to the required shape in a Jenckes machine, as shown in Fig. 55. Here, it will be seen that the shell is held in a three-jaw chuck, and the band is formed to shape by a single forming cutter. Proper location of the shell in the chuck is obtained by a gage located within the chuck.

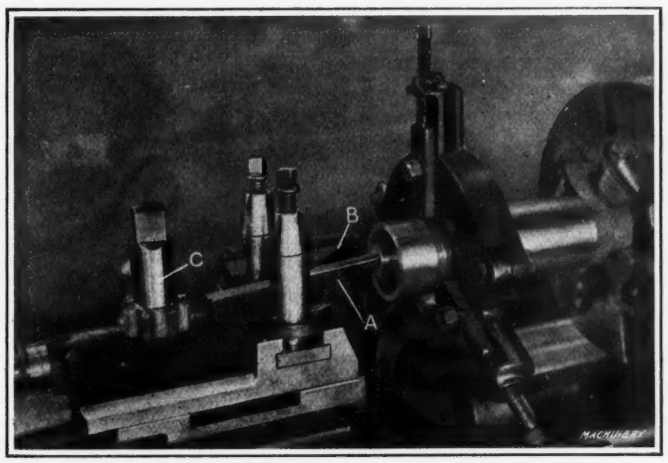


Fig. 53. Facing and threading Nose of High-explosive Shell

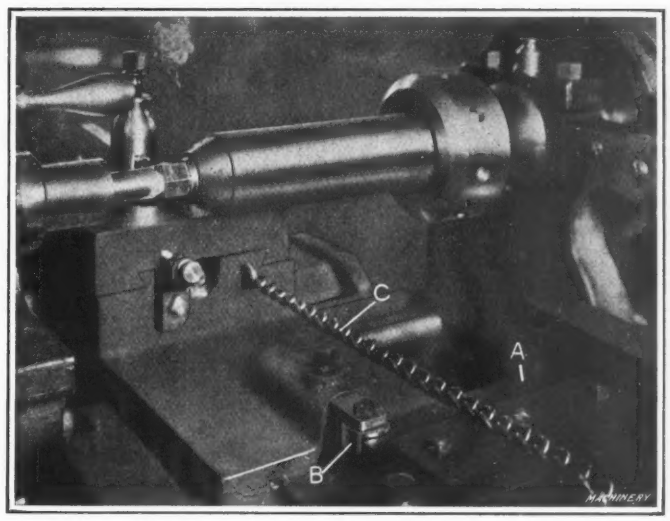


Fig. 54. Turning Radius on Nose of Shell

Machining the Adapter or Nose

The nose or adapter *A*, Fig. 48, for the Russian high-explosive shell is turned from bar stock in a 3¼-inch Gridley automatic turret lathe. The first operation after feeding the stock to the stop is drilling and rough-turning the outside and thread diameter. These operations are performed from the turret and the work speed is 120 R. P. M., the feed of the tools being 0.009 inch per revolution of the work. The tools held on the second turret face counterbore and finish-turn the thread diameter, and at the same time the forming tool is brought in to form the nose to shape. At the third station, the thread is rough-cut with a die and finished at the fourth position. The threading is performed with the work rotating at 36 R. P. M. The production on this part is six to seven pieces per hour.

The second operation on the adapter is boring out the center hole and cutting the internal thread. This is done on a

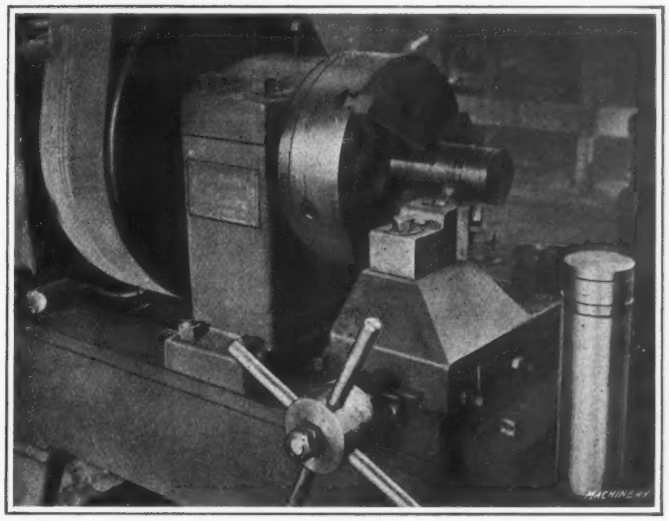


Fig. 55. Turning Copper Band on Jenckes Machine

14-inch lathe. The first step is to take a light finishing cut from the hole, after which it is threaded. The production is about four pieces per hour. The drilling, counterboring and tapping of the hole for the set-screw *B*, Fig. 48, comes next, and this is performed on a three-spindle sensitive drilling machine. The production is twenty pieces per hour. The two wrench holes *C* are then milled in a hand milling machine, one at a time. The production is sixty per hour.

MACHINING 75-MILLIMETER SERBIAN HIGH-EXPLOSIVE SHELLS

After the forging has been completed, the first machining operation on the Serbian 75-millimeter high-explosive shell shown in Fig. 56 is cutting off the open and closed ends. (See Table III.) This is done on an Espen-Lucas cold-saw, as shown in Fig. 57, at the rate of 160 per day. In this

TABLE III. ORDER OF MACHINING OPERATIONS ON 75-MILLIMETER SERBIAN HIGH-EXPLOSIVE SHELLS

Number of Operation	Character of Operation	Machine	Tools	Feed in Inches	Speed, R.P.M.	Production Per Hour
1	Cutting off Open and Closed Ends	Espen-Lucas Cold Saw	.....	.....	..	16
2	Centering	Engine Lathe	Combination Drilling and Centering	.....	..	30
3	Facing and Beveling	21-inch Engine Lathe	.....	.....	84	5.5 to 6
4	Rough-turning	17-inch Engine Lathe	.....	0.024	57	5.5 to 6
5	Semi-finish Turning	17-inch Engine Lathe	.....	0.040	71	9 to 10
6	Rough-bore, Finish-bore, Tap	Double Spindle Flat Turret	Boring Tools, Tap	.....	..	3.5
7	Rough, Finish, Knurl Band Groove	21-inch Engine Lathe	Cutting Tools, Knurl	.....	..	9 to 10
8	Finish-turning	17-inch Engine Lathe	Under-cutting Tool Turning Tool	.....	..	10 to 11
9	Final Finish-turning	17-inch Engine Lathe	Turning Tools	.....	..	12
10	Remove Base End Projection	Band Saw	.....	.....	..	120
11	Face Base End	17-inch Engine Lathe	.....	.....	..	11 to 12
12	Drill, Turn, Face, Chamfer, Bore, Neck, Thread, Form, Cut off—Ogive	4¼ Gridley Single Spindle Automatic	.....	0.008–0.012	80–140	8–6
13	Cut Internal Thread—Ogive	Automatic Threading Lathe	Circular Tool	.....	72	.....
14	Cut External Thread—Ogive	Pratt & Whitney Turret Lathe	Expanding Thread-Stud Mandrel	.....	24–60	.....

Machinery

operation, in addition to cutting off the excess stock on the open end, about 3/16 inch of stock is removed from the closed end of the forging. By referring to the illustration it will be noticed that three shells are loaded in one side of the machine by the swinging arm carrying the three gages while the saw is operating on the three shells on the other side.

Following this operation comes the centering, which is done on an engine lathe, as shown in Fig. 58. The mandrel on which the work is held carries two sets of three fingers that are expanded by a tapered draw-in bar operated by a handwheel at the rear of the spindle. A combination drilling and centering tool is used, and the production is 300 shells per day.

Turning and Boring

The shells now go to the turning department, where the first operation is facing and beveling the closed end. Reference to Fig. 56 will show that the Serbian shell has a pronounced bevel at the base end, and this is roughed out at this time and the base faced, leaving a teat about 11/16 inch diameter. The facing and beveling is done on a 21-inch engine lathe, using two tools, one of which cuts the bevel and the other faces the end. The cutting speed is 65 feet per minute; the production is fifty-five to sixty shells per day.

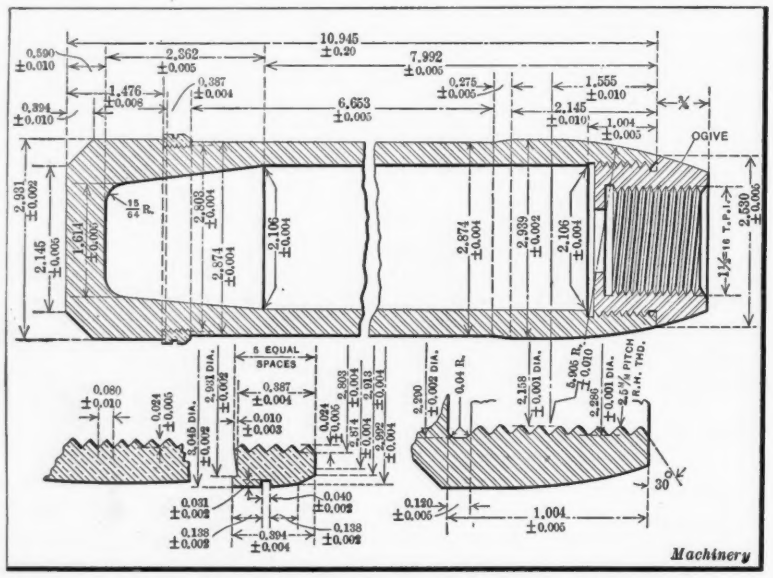


Fig. 56. Serbian 75-millimeter High-explosive Shell

The next operation is rough-turning as shown in Fig. 59. This is accomplished on a 17-inch engine lathe, at a work speed of 44 surface feet per minute. The amount of metal removed averages ⅜ inch on the diameter, and the feed is 0.024 inch per revolution of the work. This rough-turning operation leaves the shell about 0.050 inch larger than the finished size. The production is fifty-five to sixty shells per day. Following this a semi-finish cut is taken from the external diameter on a 17-inch engine lathe. For this operation the work speed is 55 surface feet per minute. The amount of metal removed is 0.025 inch on the diameter, and the feed is 0.040 inch per revolution. The production is ninety to one hundred shells per day.

The machining operations on the cavity of the shell are performed on double-spindle flat turret lathes. In the first position the operation performed is rough-boring with a single-point tool, removing ¼ inch of stock from the diameter; second, roughing out taper with a flat boring tool and recessing mouth with another tool held in the same bar; third, finish-boring full length of hole with a combination straight and taper boring tool, also boring diameter to be threaded; (The boring tool-holder used carries two blades, one set at right angles to the other; the first tool

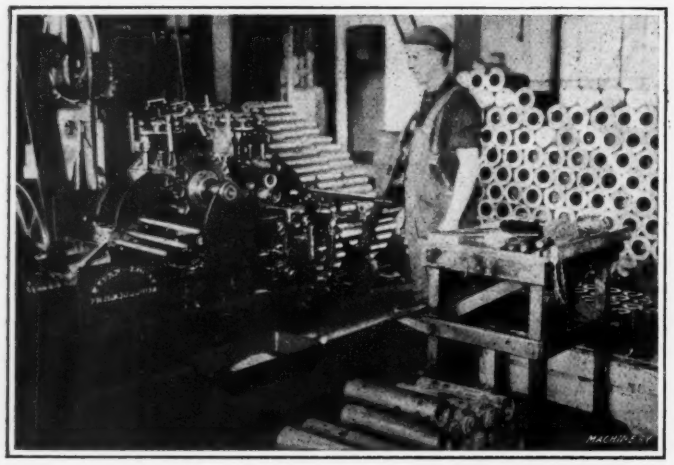


Fig. 57. Cutting off Excess Stock from Open and Closed Ends of Forging

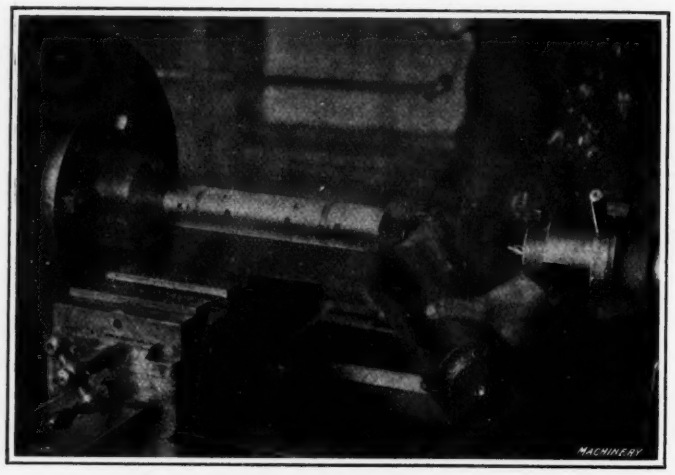


Fig. 58. Centering Closed End of Forging

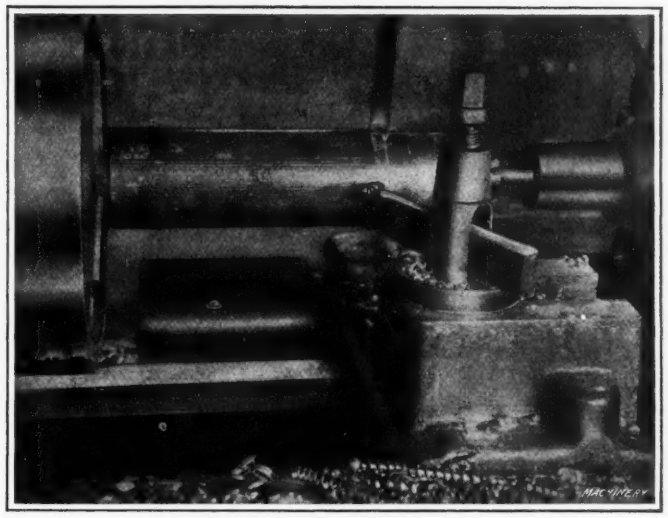


Fig. 59. Rough-turning External Diameter of Shell

bores the taper section and part of the straight section, whereas the second tool finishes the straight section only.) fourth, tapping mouth end of shell. The production is thirty-four shells per day.

A center plug is now screwed into the open end of the shell and it is taken to the 21-inch engine lathe shown in Fig. 60. The lathe is provided with a turret toolpost, and carries three cutting tools and a knurl. The first operation is to cut the groove with a broad-nose tool; second, cut two concentric rings (one for crimping in cartridge case) with a forming tool; third, under-cut base side of band groove 0.010 inch under-cut; fourth, knurl band groove. The production is from ninety to one hundred shells per day. The shell is now taken to a 17-inch engine lathe, where a light cut is taken from the external diameter, leaving it 0.015 inch over size. The

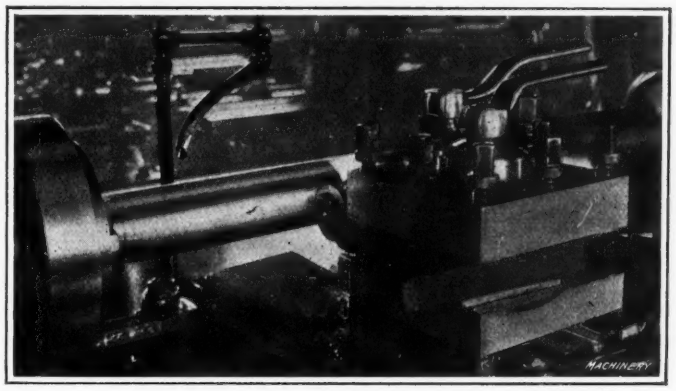


Fig. 60. Turning and Knurling Band Groove

turning commences at the rifling band groove and terminates at a point about two inches from the nose. The production is 100 to 110 shells per day. Following this is the final finishing. This is also accomplished in a 17-inch engine lathe. Two tools are used for this operation; one is set to the finished size of the shell at the base end back of the band groove, and the other is set for the reduced size. The purpose of this reduction is to allow clearance for the shell in passing through the gun. The production is 120 shells per day. The projection on the base end of the shell is now removed on a band saw. This is done at the rate of two shells per minute. After sawing off the center projection, the base end is squared up on a 17-inch engine lathe. The turret toolpost carries two tools; one of these faces the end and the other trues up the bevel. The production is 110 to 120 per day. Before any other operations are performed on the shell, the ogive is assembled.

Machining Ogive for Serbian High-explosive Shell

The ogive which fits in the nose of the Serbian 75-millimeter high-explosive shell is turned out from bar stock containing about 50 points carbon. The first operation is performed on a 4¼-inch Gridley single-spindle automatic. The bar is fed to the stop located on a "corner" of the turret slide, and the first operation is to drill the small hole, and at the same time take a light cut from external diameter and face end of work; second, bore hole from turret, also chamfer inside with a hook tool; third, neck at base of thread with a regular Gridley internal necking tool, and at the same time form outside diameter to full width with a forming tool carried on the cross-slide; fourth, cut off. For centering, boring and facing, the stock revolves at 140 R. P. M. and the feed is 0.010 inch per revolution. For forming, the speed is slowed down to 80 R. P. M. and the feed to 0.008 inch per revolution. The cutting off is done at a spindle speed of 140 R. P. M. with a tool feed of 0.012 inch. Production is eight per hour.

The cutting of the internal thread is the next operation, and this is done on an "Automatic" threading lathe, using a circular tool on the bar. The spindle of the machine rotates at 72 R. P. M. and it takes from fifteen to twenty passes of the tool to complete the thread. The production averages six pieces per hour. Following this, the thread on the external diameter is cut. This is accomplished on a turret lathe, where the work is held on an expanding threaded-stud mandrel. The first operation is to face the seat on the under side of the ogive that comes in contact with the front end of the shell; second, thread external diameter; third, chamfer thread and burr hole. The facing and burring operations are accomplished at a spindle speed of 60 R. P. M., whereas for threading the speed is cut down to 24 R. P. M. This finishes the operations on the ogive with the exception of assembling it into the shell and taking a cut over the circular portion.

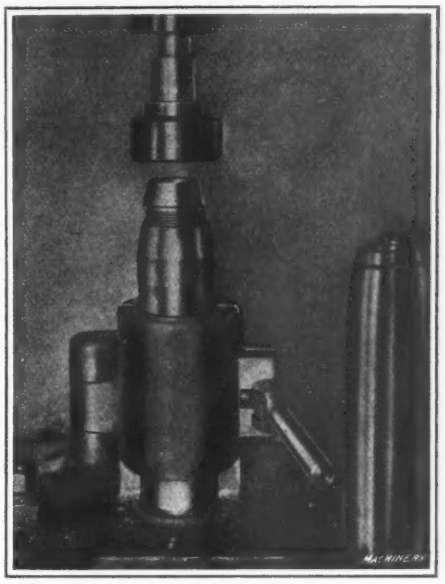


Fig. 61. Assembling Ogive in Shell Nose

Setting in the Ogive

After the ogive has been completely machined, as previously described, it is assembled in the nose of the shell. The assembling is done on a drilling machine as shown in Fig. 61. The shell is gripped in a hinged fixture fastened to the table of the drilling machine and a special tool similar in shape to an inverted cone, the inside surface of which is serrated, is used to assemble the ogive in the shell. The ogive

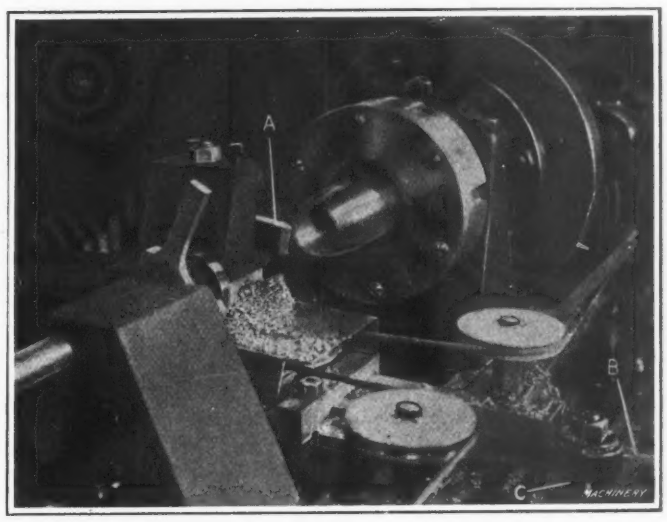


Fig. 62. Turning Ogive in Open End of Shell

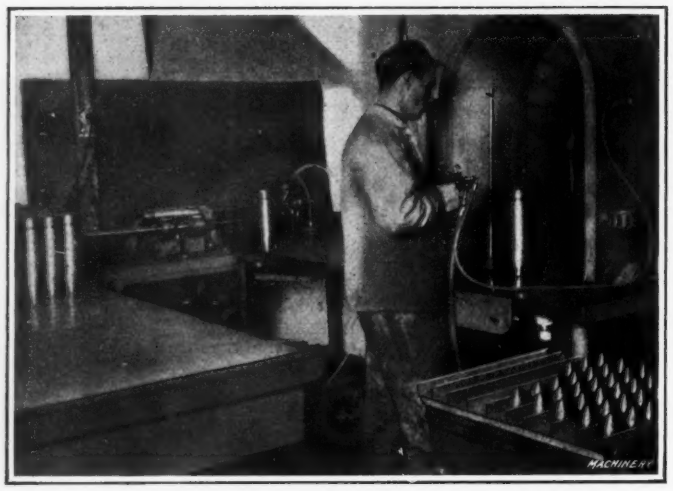


Fig. 63. Spraying Interior and Exterior of Shell with Copal Varnish

is started into the shell by hand and then the tool is brought down in contact with it, driving it down to the seat.

The shell is now taken to a 17-inch engine lathe where the radius is turned, as shown in Fig. 62. Here it is gripped in a a collet chuck, being located centrally in this chuck by means of a special gage located on the tailstock spindle. After clamping, the turning tool *A* is brought in contact with the work and is guided in its operation by means of a former-plate *B* that is fastened to a fixture held to the bed of the lathe. The movement of the cross-slide is controlled by a roller *C* that contacts with this former-plate, the latter being kept in contact with the plate by means of two ropes to which weights are attached and which run over pulleys, as illustrated. The production is seventy per day.

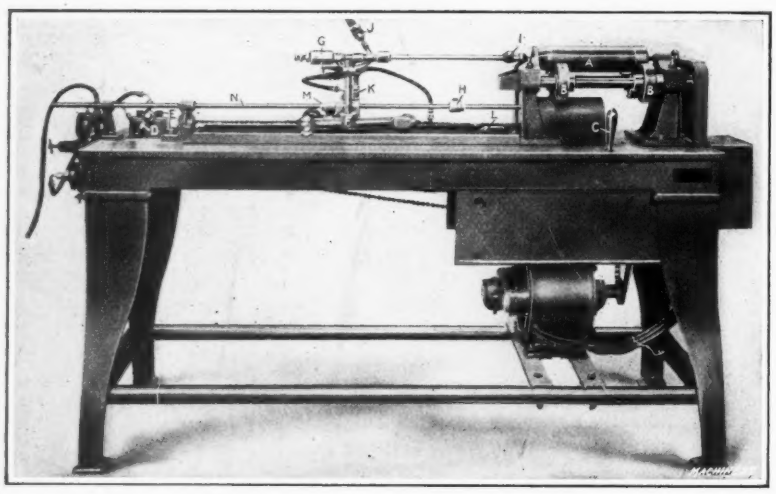


Fig. 64. De Vilbiss Spraying Machine for coating Interior of High-explosive Shells

Following the turning of the nose, the copper band is now pressed into the groove in a West Tire Setter Co.'s banding press. The bands are annealed before being pressed on the shell and two squeezes are necessary to compress the band into the groove. The copper band is now turned to shape in a 14-inch engine lathe carrying a special forming tool that covers the entire width of the band. This operation is handled at the rate of ninety shells per day. The shells are now inspected before they go into the hands of the government inspector. The inspection operation consists in checking up the diameter of the band and the ogive to see that they are held tightly in place. The shell is now stamped on a Noble & Westbrook stamping machine. The stamp is in the form of a roll that is passed over the end of the shell, pressure being applied by means of a foot-treadle. Prior to the varnishing which follows, the shells are washed, after which they are dried.

Varnishing Interior and Exterior of Serbian High-explosive Shells

The shells now go to the lacquering and spraying department where they are sprayed inside and outside and painted on the outside previous to shipment. For the spraying of the outside of the shell, a special De Vilbiss spraying torch is used as shown to the right in Fig. 63, whereas the internal diameter is sprayed on a special machine shown in the background of the same illustration. Copal varnish is used for spraying; this prevents the high-explosive from contacting with the shell.

The operation of the internal spraying device is more clearly shown in Fig. 64. For this operation the shell *A* is placed on two pairs of rollers *B*, which are rotated by a one-half horsepower electric motor. The shells revolve at the rate of 300 R. P. M. and they are placed on the rollers and removed from them after the spraying is done and while the rollers are still in motion. The rollers are driven by means of a chain from the motor through a countershaft. The operation of the spraying member of the machine is as follows: With the rollers in motion and the machine in the position shown in Fig. 64, lever *C* is thrown to the left to start the machine. This releases a catch that holds lever *D* in a neutral position. The releasing of the catch allows a coil spring to pull lever *D* into the position shown, this lever being connected to the valve *E*. When this valve is operated, the air passes through it to a cylinder provided with a piston, the forward motion of which operates a cone clutch that starts carriage *F* moving to the right. When the carriage *F* strikes stop *H*, the rod upon which it is held moves forward with the carriage until the coil spring is pulled over the center line of lever *D*, at which point valve *E* is operated to return the carriage. At the same time that carriage *H* starts to move to the left, the air valve starts the spraying device *G* to work.

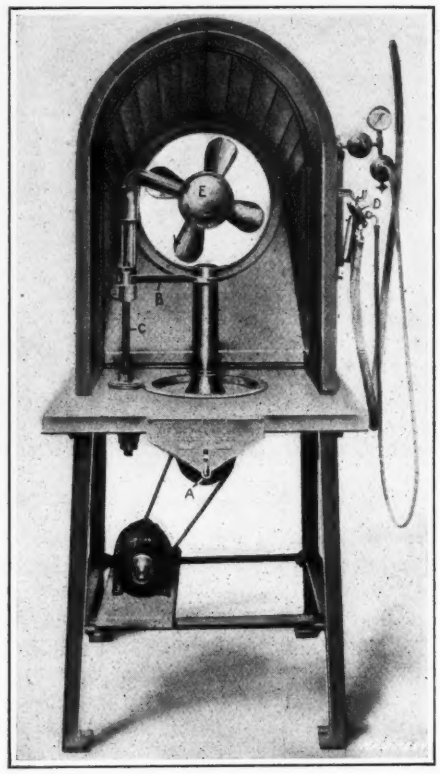


Fig. 65. De Vilbiss Spraying Device used in coating Exterior of High-explosive Shells

There are two nozzles in the end of torch *I* that throw a stream of varnish in two directions. The end of the shell as well as the sides are covered as the carriage moves to the left. The varnish or other material used flows down through the flexible metal hose *J* from a five-gallon container suspended above the machine. When the spraying torch reaches the point where the shoulder of

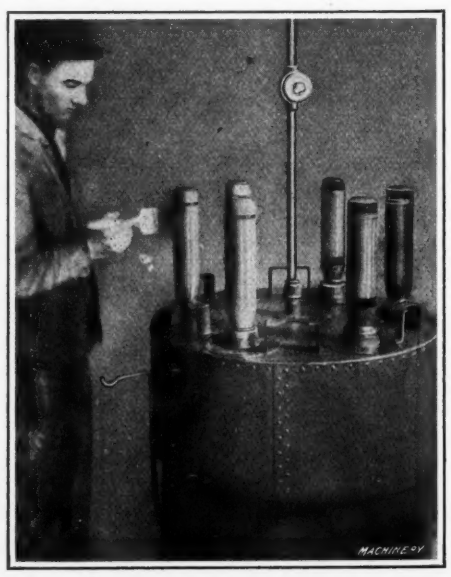


Fig. 66. Painting Exterior of High-explosive Shells

the ogive is coated, a cam mounted on the bed of the machine trips the air valve *K*, which stops the spraying. This valve, of course, is in circuit with the valve which starts the spray so that the air passes through both of them. (Valve *K* is opened on the forward stroke by cam *L*, but the other valve is closed at that time and the spray does not start.) The carriage continues to the left until it strikes stop *M*, which moves the rod *N* back to the point where the lever *D* is pulled back by the spring. A trip serves as a stop to hold lever *D* in a neutral position until it is again thrown. The throwing of lever *D* into the neutral position releases the air pressure on the piston holding the clutch in engagement, and a spring pushes the clutch out, stopping the motion of the carriage. The production is 400 shells per day.

The special De Vilbiss machine for spraying the exterior of high-explosive shells is shown in Fig. 65. The spraying of the outside is done after the inside has been sprayed. In spraying, the shell, as shown in Fig. 65, is placed on a vertical revolving spindle which is driven by a one-sixth horsepower electric motor at a speed of about 250 R. P. M. through a belt and friction disk drive. The amount of spray is adjusted by changing the position of the wheel which engages with the friction disk. Lever *A* serves to move the wheel in and out of engagement and is used to stop and start the machine between the spraying of the shells. The adjustable guard *B* is mounted on post *C* and swings in against a stop which pulls it into position and covers the copper driving band of the shell, protecting it from the varnish. The shell is sprayed, while revolving, with a De Vilbiss standard type L "Aeron" shown at *D*, the operator holding this device in his hand as shown in Fig. 63. The exhaust fan *E* removes the vapors caused by the spraying operation. This fan is operated by a one-half horsepower motor, entirely enclosed to protect it from the vapors, and the motor is automatically cooled by the clean air being drawn through it by the action of the fan. The production on this machine is between 400 and 500 shells per day.

After spraying, the shells are placed in a Steiner baking oven heated to 300 degrees F. where the shells are baked for eight hours. They are then taken to the Canadian Fairbanks-Morse painting machine shown in Fig. 66 where they are given a coat of yellow paint. This painting machine consists of a stand on which there are six spindles, each of which rotates continuously. The shells are placed upon the spindles, and as they rotate the painter holds his brush on the shell and applies the yellow paint. The band is not

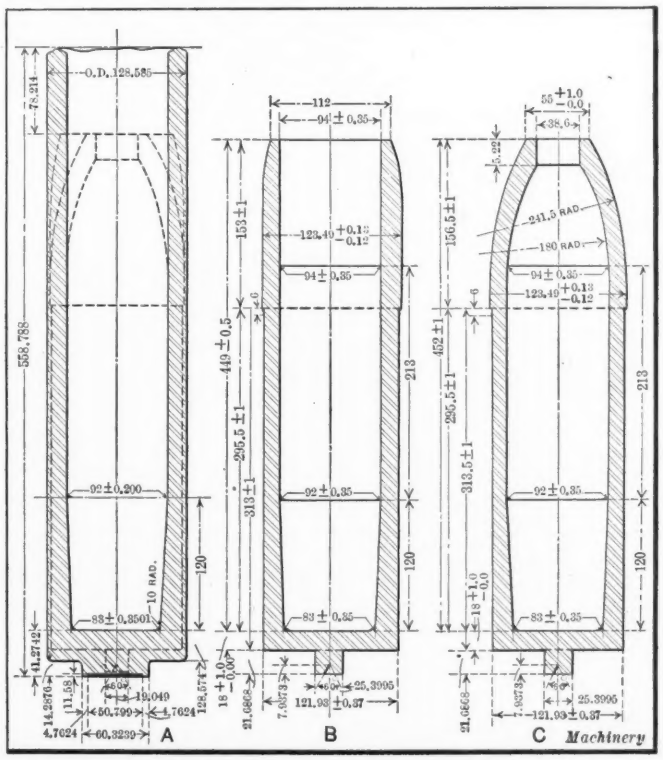


Fig. 67. Principal Dimensions of Forging and Condition of French 120-millimeter High-explosive Shell after First Series of Machining Operations

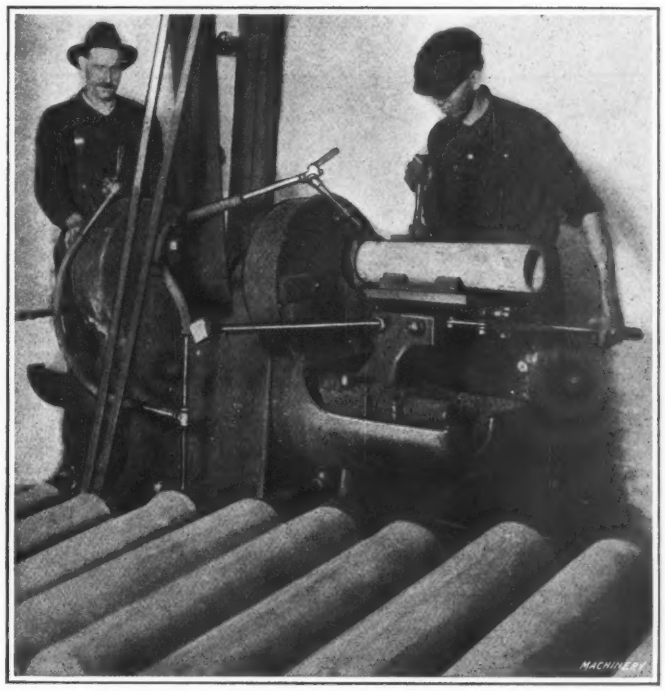


Fig. 68. Grinding Base End of 120-millimeter French High-explosive Shell Forgings in a Gardner Disk Grinder

painted. One man can handle 250 shells per day with this machine, although it is usually used with a battery of two painters and one cleaner, when the average production is 750 shells. Once more the shells are placed in drying ovens that are kept at a temperature of 150 degrees, and ten hours in these ovens completes the drying of the shell. It takes twenty hours to dry in the atmosphere; therefore, this cuts the time exactly in half. After drying, the shells are wrapped in oil paper and packed ready for shipment.

MACHINING FRENCH 120-MILLIMETER (4.72 INCH) HIGH-EXPLOSIVE SHELLS

The following description applies to the manufacture of the French 120-millimeter high-explosive shell which is made from a seamless steel forging of the proportions shown at *A* in Fig. 67. The forging is machined to the shape shown at *B* and is then nosed-in, after which a second series of operations is performed, bringing it to the shape shown at *C*. The first operation is to pickle the forgings to remove the scale. This is done in a sulphuric acid solution of the following proportions: sulphuric acid 1 part, water 10 parts. The temperature of this solution should not be raised above 150 degrees F., as a temperature higher than this produces fumes that are very annoying. The forgings are pickled in this solution for one hour and then washed in a bath of hot lime-water to remove all traces of the acid.

Sorting and Grinding Base End

The next operation consists in sorting the forgings for size, with particular reference to the diameter of the cavity. The forgings are received in the plant in three lots: those exactly 94 millimeters (3.7 inches), those below, and those above this dimension. As a certain thickness of wall must be maintained in this shell, the variation on the inside diameter of the forging is carried to the external diameter, and on forgings in which the cavity is larger than the exact size of 94 millimeters, the external diameter is made slightly larger to allow for this. It is therefore necessary that the forgings be sorted and machined in different lots. After sorting, they are taken to the Gardner double-spindle disk grinder shown in Fig. 68, where the projection on the closed end is surfaced for centering. Here the forging is held in a special cradle fixture fastened to the swinging table and is held in place by a clamp as shown. The wheel used is a carborundum cylinder wheel, 16 inches diameter, with a 2-inch rim. The speed of the wheel is 2500 R. P. M., the amount of stock removed 1/32 to 1/16 inch, and the production about thirty per hour. The complete order of operations is given in Table IV.

TABLE IV. ORDER OF MACHINING OPERATIONS ON FRENCH 120-MILLIMETER HIGH-EXPLOSIVE SHELL

Number of Operation	Character of Operation	Machine	Tools	Feed, Inches	Speed, R.P.M.	Production Per Hour
1	Disk Grinding Base End	Gardner Grinder	"American" Wheel	.....	2500	30
2	Cut off Open End	Engine Lathe	"Cyclops" No. 5	Hand	56	15
3	Drill Center	U. S. Elec. Tool	Center Drill	Hand	Work 60 Drill 7250	45
4	Face Closed End	Engine Lathe	"Cyclops" No. 5	Hand	.....	6
5	Rough-turn	"Lo-swing" Lathe	"Cyclops" No. 5	.....	56	4
6	Nose-in Open End	Beaudry Hammer	.....	.....	.....	30
7	Face End and Bore	Engine Lathe and J. & L.	.....	.....	.....	15
8	Heat-treat	Frankfort Furnace	.....	.....	.....	25
9	Inspect for Hardness	Brinell Test	.....	.....	.....	60
10	Recenter Base End	Williams Tool Co.	Center Drill	.....	.....	200
11	Bore and Thread Nose	Flat Turret Lathe	Murchey Taps	.....	.....	7
12	Finish-turn	"Lo-swing" Lathe	"Novo Superior"	0.020	40	4
13	Grind	Norton Grinder	Norton Wheel	.....	.....	8
14	Pressing Copper Band	West Tire Setter Co.	.....	.....	.....	...
15	Turning Copper Band	16" Engine Lathe	.....	.....	.....	20
16	Cutting off Projection	Williams Cutting-off Machine	.....	.....	.....	24
17	10 Testing Operations	Gages and Weighing Scales	.....	.....	.....	...
18	Testing for Strength	Metalwood Co. Press	.....	.....	.....	...

Machinery

Cutting Off Open End of Shell and Centering Closed End

From the disk grinder, the forgings are taken to the lathe shown in Fig. 69, where the open end is cut off, bringing the forging to the desired length. The forgings are held on an expanding mandrel operated by a special air chuck as shown in Fig. 70. Here the forging is shown by heavy dotted lines, and as will be seen it is gripped near the open end by an expanding collar *A* provided with a series of serrations around its periphery. The forging is located by adjusting screw *B* and is forced up tight against this stop before the air cylinder is operated. Clamping is effected throughout rod *C*, which is connected to collar *A* by pin *D*, rod *C*, in turn, being drawn back to expand collar *A* by a Hannifin air chuck cylinder located at the rear end of the machine spindle. For this operation, the work is rotated at 70 feet surface speed and the production is fifteen per hour. After cutting off, the shell is gaged to length by the gage shown in Fig. 71. This gage has graduations on the bar, giving the limits.

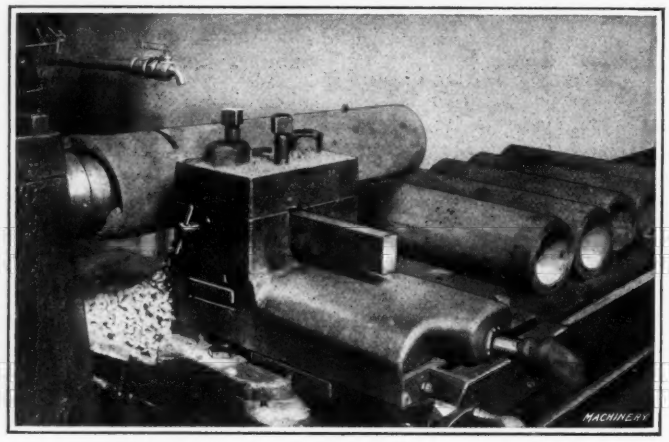


Fig. 69. Cutting off Open End of High-explosive Shell Forging

The centering of the closed end is the next operation. This is accomplished in an engine lathe in an interesting manner as shown in Fig. 72. The lathe is provided with a Hannifin air chuck, operating an expanding mandrel of the type shown in Fig. 73, on which the forging is held. This mandrel differs somewhat in construction from that shown in Fig. 70 in that in addition to clamping the forging it is also required to center it accurately from the internal diameter. In construction, this mandrel comprises a main sleeve *A*, which is screwed onto the spindle of the machine, and inside of which passes a rod *B* and sleeve *C*. Rod *B* and sleeve *C* are provided with tapered bearings that operate three clamping blocks *D* and *E* against the tension of flat springs *F* and *G*. These blocks, of course, are located equidistantly around the circumference of the mandrel and engage the interior of the forging near the base end and about 1½ inch from the open end, respectively. Sleeve *C* of the chuck is forced forward when rod *B* is drawn back and *vice versa*.

Centering is done with a United States electric drill held in a cradle *A*, which is fastened to the cross-slide of the lathe and consequently moves with it. As shown in Fig. 72, the centering tool is guided by plate *B* which is fastened to the

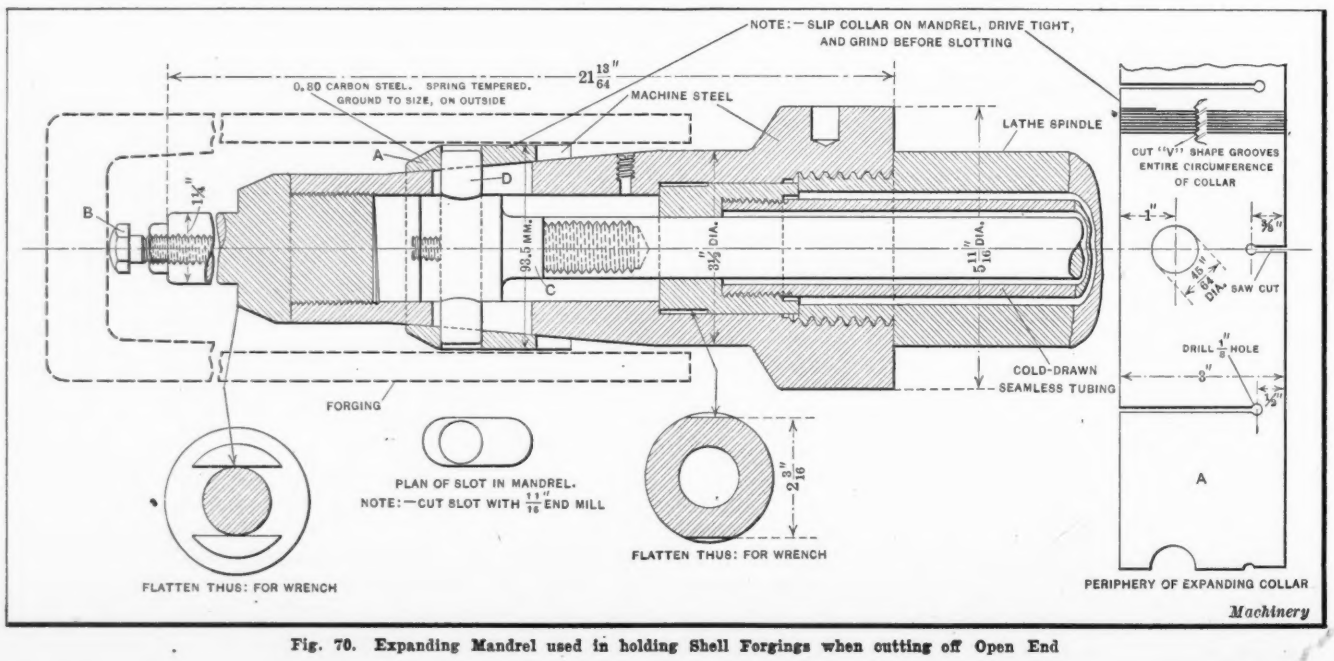


Fig. 70. Expanding Mandrel used in holding Shell Forgings when cutting off Open End

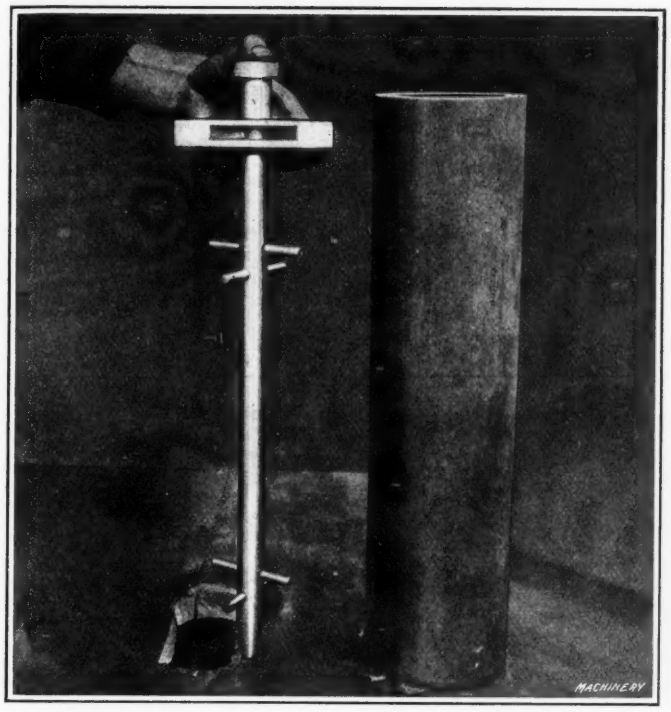


Fig. 71. Gage used in testing Length of Trimmed Forgings

cross-slide and holds the tool in line with the axis of the machine and drill spindles. The center hole is drilled and countersunk 5/8 inch deep. The work is rotated at 25 feet surface speed and the drill at 175 surface feet. The production is forty-five shells per hour.

Facing Off Closed End and Gaging for Length

After centering, the closed end of the forging is faced off to the required length as shown in Fig. 74. In this operation, the forging is held on an expanding air-operated mandrel of the type shown in Fig. 73. The desired length is secured by a swinging tool-setting gage *A* held in a bracket that is fastened to the bed of the lathe. In facing, from 1/2 to 7/8 inch of stock is removed; the work is rotated at 70 surface feet per minute and the feed is by hand. The production is six shells per hour.

The next operation consists in gaging the trimmed forgings for overall length as shown in Fig. 75. Referring to this illustration, it will be noted that the gage used consists of a plate, two pillars and a cross-bar. The plate is provided with a slot so that the teat on the end of the shell does not interfere with the correct measurement of the overall length. The gage used in testing the length of the shell after cutting off the open end is also shown in this illustration to the right. The allowable limit on length is 4 millimeters.

Rough-turning External Diameter

The rough-turning of the external diameter is accomplished on a "Lo-swing" lathe as shown in Fig. 76. Two tools are used for this operation that remove about 3/16 inch of stock from the diameter. One tool starts at the center of the forging and the other works from the closed end, so that the time required to turn the entire length of the shell is only equal to that which would be necessary to turn one-half the length with one tool. For this operation the shell is held on an expanding mandrel of the type shown in Fig. 73. The first cutting tool turns straight for a short distance until it approaches the nose, when it is backed out to enlarge the shell

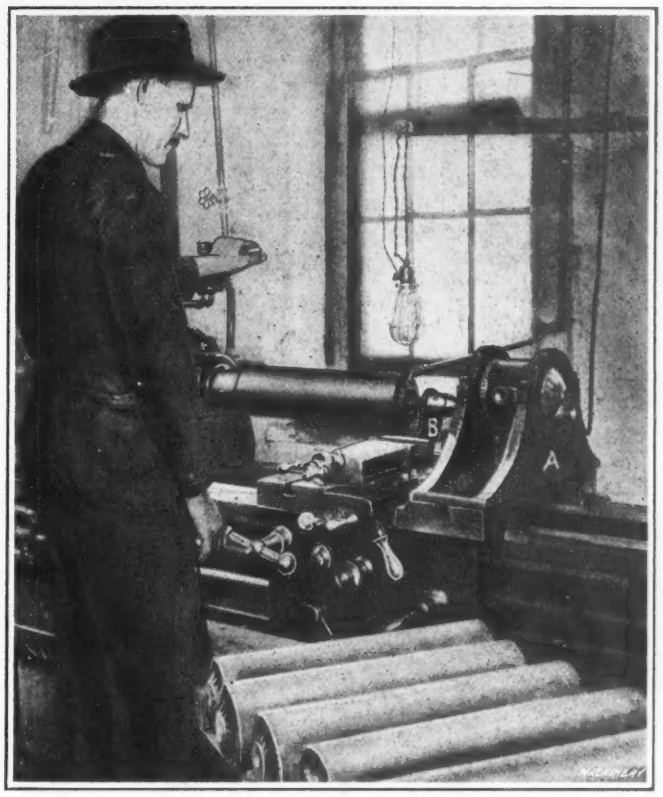


Fig. 72. Centering Closed End of Forging

at that portion where it is nosed-in. The shells are turned in this operation to within 2 millimeters, 0.0787 inch, of the finished size, the remainder being left for grinding. The test for diameter is then made with a set of Johansson gages, after

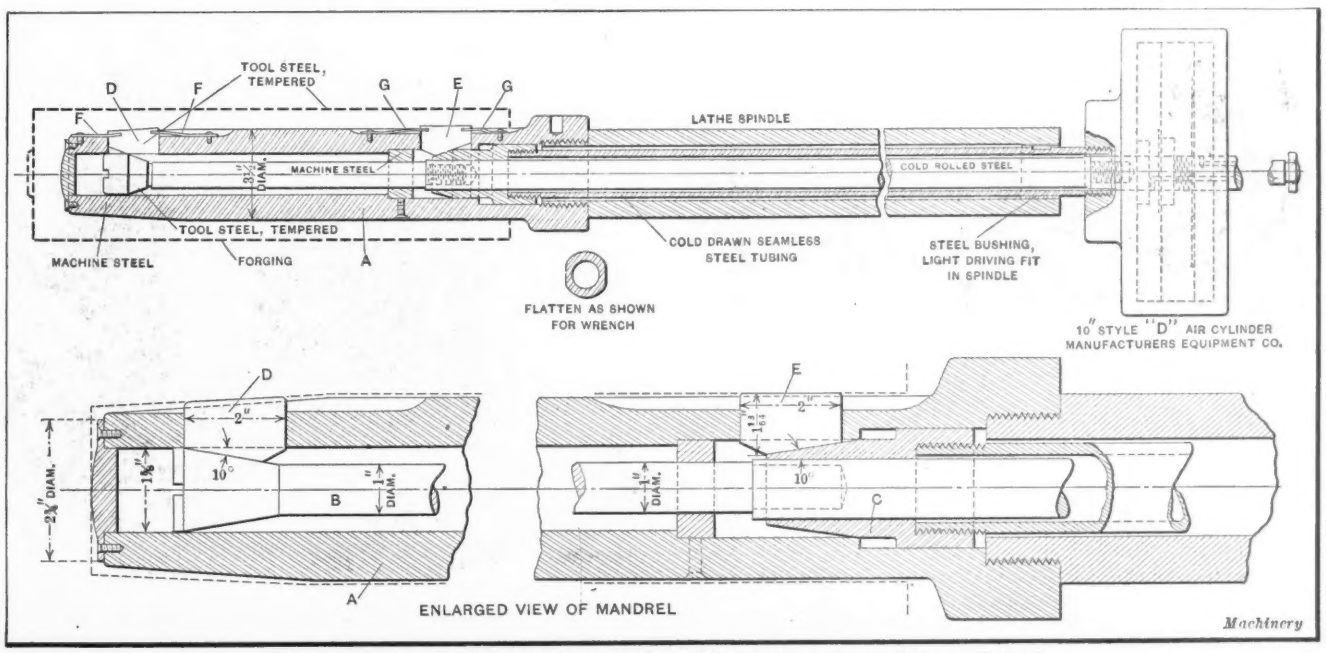


Fig. 73. Air-operated Mandrel used in holding Shell Forgings when centering and turning

Fig. 74. Facing off Closed End of Forging to Length

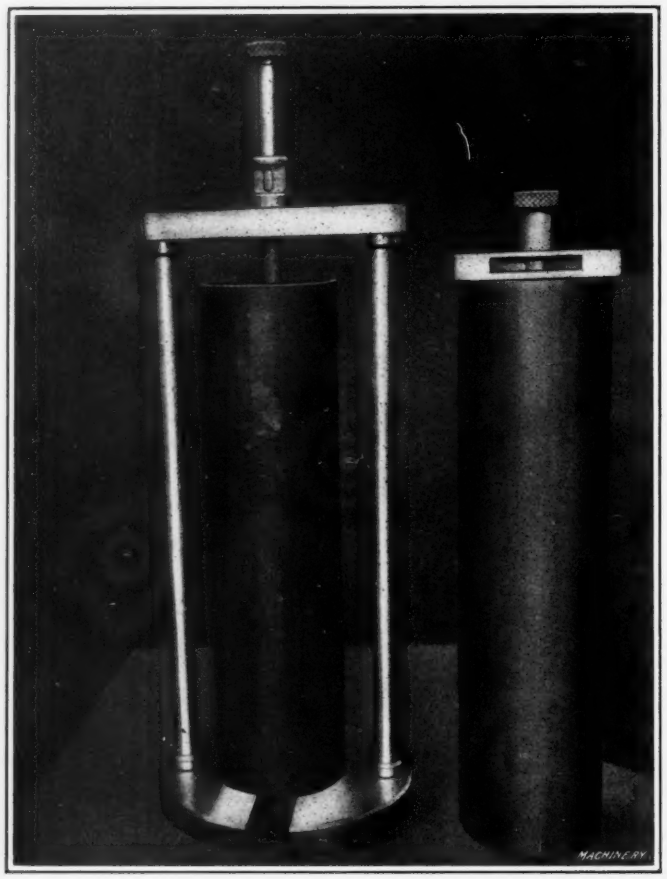


Fig. 75. Gaging Total Length of Trimmed Forging prior to turning

which the shell is heated for nosing-in. The production is four per hour.

Nosing-in Open End and Heat-treating

For nosing-in, the shell is heated for a distance of six inches back from the open end in the Frankfort furnace shown in the background in Fig. 77. The shells are left in the furnace for thirty minutes and heated to a temperature of 1600 degrees F. The furnace is heated by natural gas, and holds ten shells at one time. The nosing-in operation is accomplished in a 500-pound Beaudry hammer as shown in Fig. 77. For this work four men are required. One rotates the shell on its axis; another feeds the shell into the hammer dies, which are split and of the right shape; the third operates the hammer; and the fourth takes the nosed-in shell out of the hammer and brings another one to the machine ready for nosing-in. The nosing-in is started with light blows, so as to make the metal flow as evenly as possible; the blows are then increased in severity until the shell has received about twenty-five blows, which is ordinarily sufficient to complete the operation. An improvement made over this method, however, consists in eliminating one man by rotating the shell on its axis

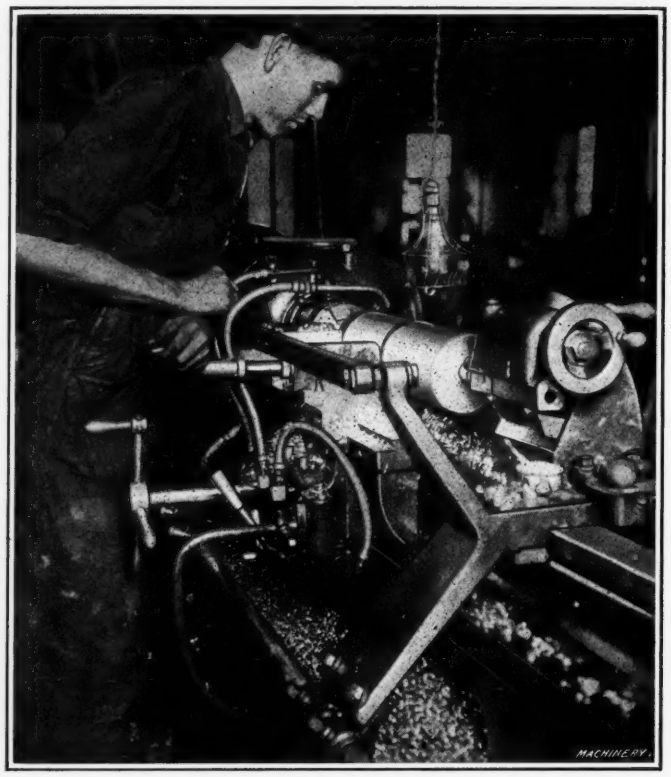


Fig. 76. Rough-turning External Diameter in a "Lo-swing" Lathe

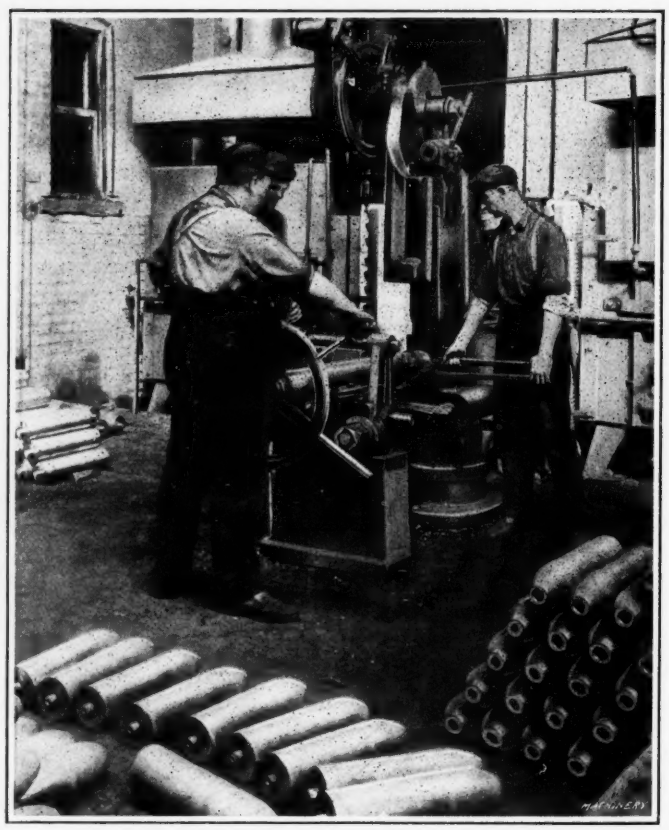


Fig. 77. Nosing-in Open End of Shell in a Beaudry Hammer

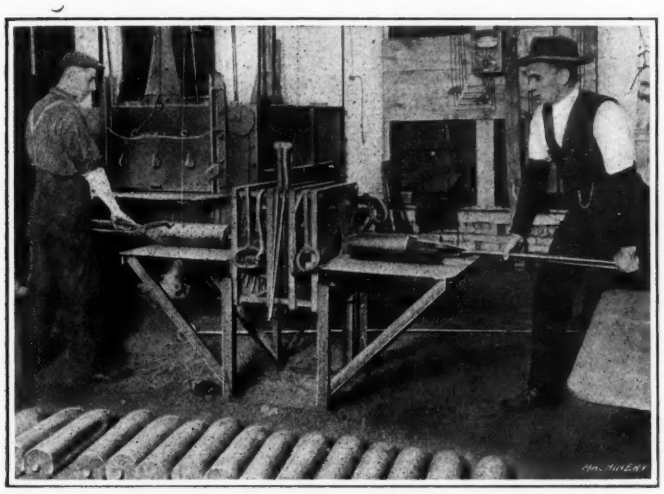


Fig. 78. Heat-treating Furnace and "Brush" for removing Scale prior to immersing Heated Shell in Cooling Bath

by means of an air drill. The production is thirty per hour.

After nosing-in, the shell is taken to a lathe where it is gripped in a chuck, the nose bored out, and the end faced off to length. The next operation is heat-treating. The heating is done in a Frankfort furnace of the type shown to the left in Fig. 78. The shell is left in the furnace for twenty-five minutes at a temperature of 1800 degrees F. As soon as the shell reaches the desired temperature, it is quickly removed

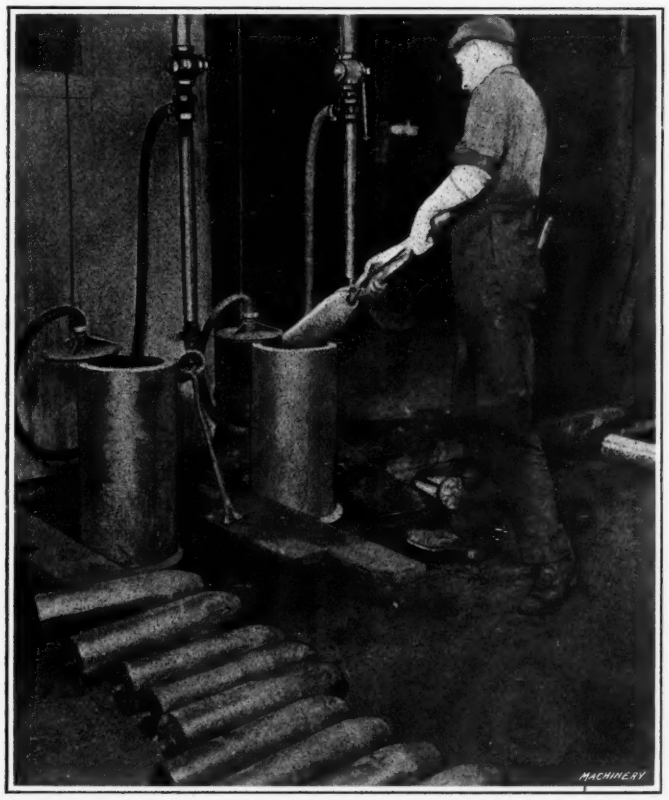


Fig. 79. Dipping French High-explosive Shells in Special Cooling Bath

from the furnace and placed in the cooling bath, shown in Fig. 79 and in detail in Fig. 80. Formerly the brushing device shown in the foreground of Fig. 78 was used to remove the scale, but this has been found unnecessary. Each cooling bath accommodates only one shell and is so arranged that the water circulates inside the cavity as well as around the external circumference. The shells are left in the cooling bath for five minutes, after which tempering follows. The quenching device shown in Fig. 80 does not provide for rotating the shell when cooling. A later improved device incorporates a rotating table for revolving the shell and thus obtaining a more uniform hardness. The tempering operation which follows is accomplished in a Frankfort furnace, where the shell is heated to 970 degrees F. and then taken out and allowed to cool off in the air.

Inspecting for Hardness

The final inspection for hardness is accomplished by means of a hydraulic testing machine, working on the Brinell ball principle, as is shown in Fig. 81. The ball used is 10 millimeters in diameter, and the pressure is 3000 kilograms (6613.8 pounds) for a period of fifteen seconds. The diameter of the impression made with this ball must be 3.4 millimeters (0.1139 inch). This corresponds to a hardness on the Brinell chart of 321. After this testing operation, the shells are then

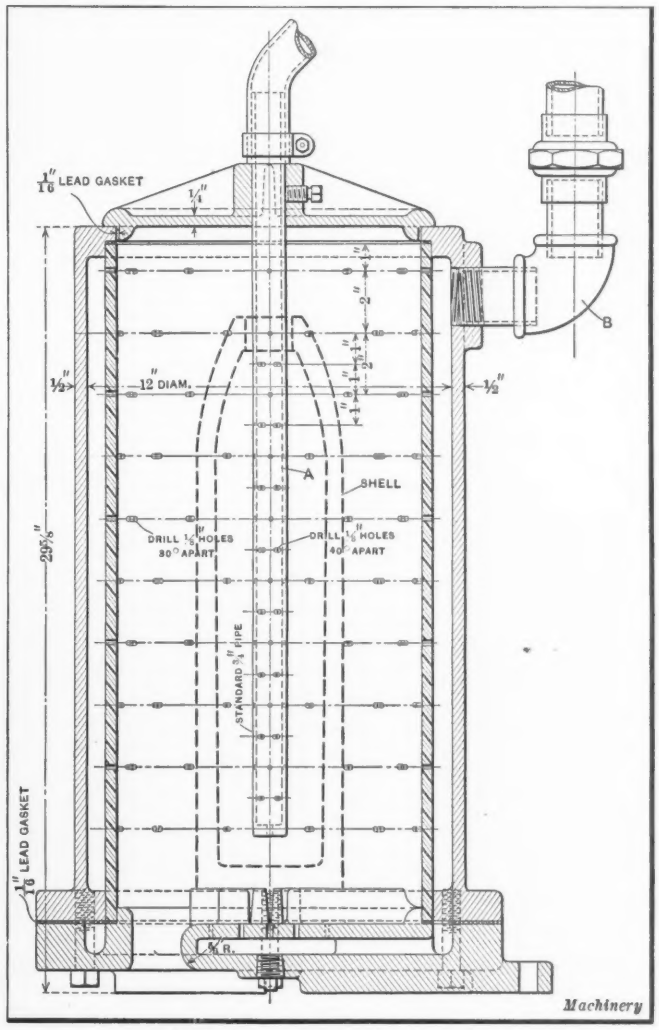


Fig. 80. Details of Cooling Bath shown in Fig. 79.

ready for grinding as will be described later. This Brinell test factor indicates an ultimate strength of about 124 kilograms per square millimeter.

Pickling and Drying Partially Machined Shells

After heat-treatment and testing for hardness, the shells are pickled to remove the scale formed in heat-treating, and dried before any further machining operations are performed on them. For pickling, the shells are placed, open end up,

Fig. 81. Testing Hardness of French 120-millimeter High-explosive Shells

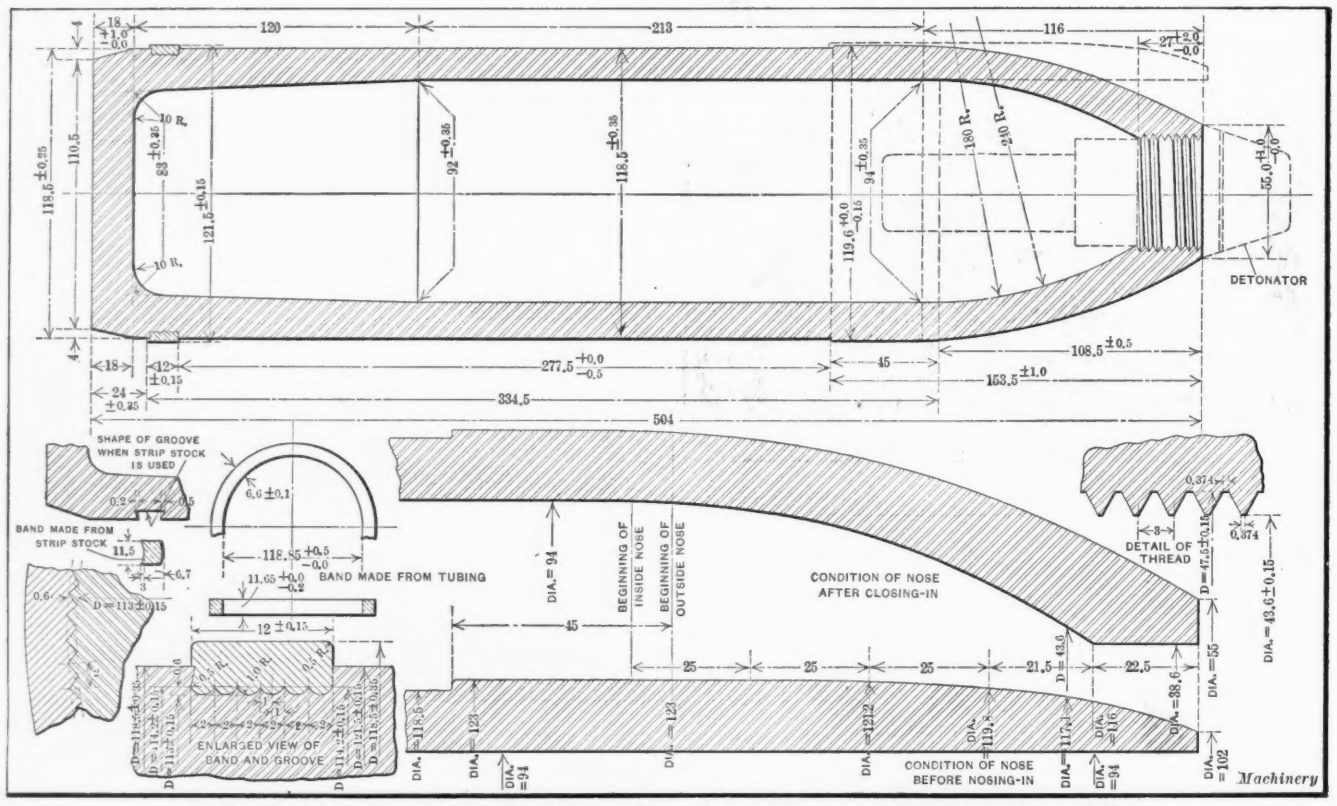

DETONATOR
SHAPE OF GROOVE WHEN STRIP STOCK IS USED
BAND MADE FROM STRIP STOCK
BAND MADE FROM TUBING
ENLARGED VIEW OF BAND AND GROOVE
DETAIL OF THREAD
CONDITION OF NOSE AFTER CLOSING-IN
CONDITION OF NOSE BEFORE NOSING-IN
BEGINNING OF INSIDE NOSE
BEGINNING OF OUTSIDE NOSE
Machinery

Fig. 82. Illustration showing French 120-millimeter High-explosive Shell, giving Finished Dimensions and Limits

in a wooden rack and are immersed in a bath consisting of ten parts water to one part sulphuric acid. The shells are left in this solution for forty-five minutes, and in lifting them out they are tipped so that the pickling solution runs out quickly. After immersing in the acid bath, the shells are washed in a solution of strong lime-water, then in clear running water, and then dried in a coke furnace. This furnace is 24 inches wide, 12 inches high by 48 inches long, and is tilted from the floor so that the shells, when fed in at one end, roll down and out of the other. The temperature of this coke furnace, which is simply an ordinary box furnace heated by coke, is about 400 degrees F. It holds ten shells, which are left in it for forty minutes, after which they are taken out and allowed to cool in the air.

Boring and Threading Nose End

Following the pickling of the partially machined shell, the first operation consists in recentering the base end, which is done on a Williams Tool Co. cutting-off machine that has been fitted up for centering. Here a light cut is taken to true up the center. The time required is about ten seconds per shell.

Following this, the shells are taken to the Jones & Lamson turret lathe shown in Fig. 83. For this operation, the work is held in a "Whiton" chuck and supported by a three-roll steadyrest. The first operation consists in rough-boring the hole in the nose; second, finish-boring hole with an expanding boring-bar; third, reaming to 43.6 millimeter diameter; fourth, rough-tapping with Murchey collapsible tap; fifth, fin-

Fig. 83. Boring and threading Open End of Shell on Jones & Lamson Single-spindle Turret Lathe

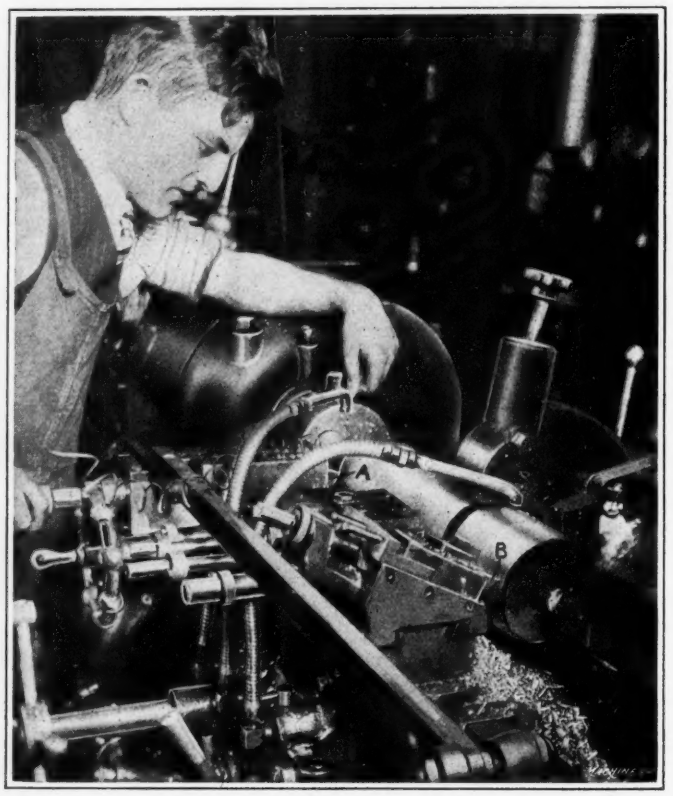


Fig. 84. Finish-turning External Diameter in a "Lo-swing" Lathe at the Rate of Four Shells per Hour

ish-tapping with Murchey tap. For boring, the work is rotated at 50 surface feet per minute, and for tapping at 30 feet per minute. The production is seven shells per hour from each machine. The shells are now removed from the chuck and the thread finished to exact size by means of a master tap. This is really an inspection operation. The shells are now washed in a steam bath to remove all the oil and grease and are then dried out thoroughly. Hardened center plugs are now screwed into the open end of the shell to serve as a center point when grinding and turning the external surface in subsequent operations.

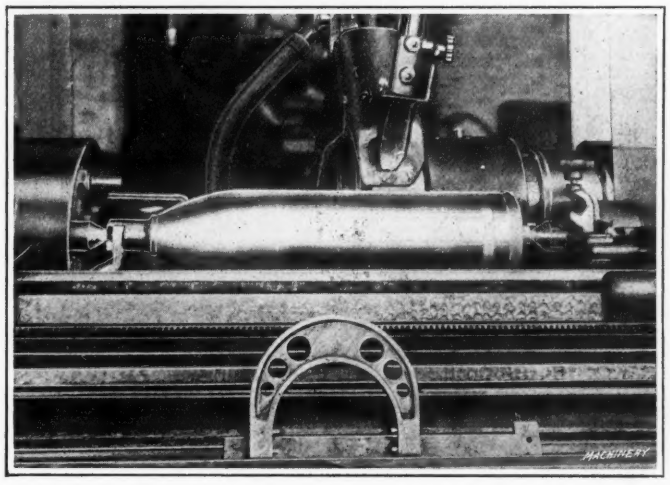


Fig. 85. Grinding Body of Shell on Norton Plain Grinding Machine

Finish-turning External Diameter of Shell

The finish-turning operation is done on the "Lo-swing" lathe shown in Fig. 84. Here two tools are used to finish the straight portion, and when these have traveled about 6 inches on the shell, the third tool *A* comes into operation to turn the radius on the nose. Another tool, not shown, turns the band groove to width and depth, then an under-cutting tool is brought in to finish the under-cut, and finally the groove is knurled. The last operation is to bevel the closed end with tool *B*. When a copper ring is used for the rifling band, only one side of the groove is dovetailed, but when a copper strip is used, both sides must be dovetailed. For the various turning operations, the work is rotated at a surface speed of 50 feet per minute, and the feed for the external straight turning is 0.020 inch per revolution. The production is four shells per hour.

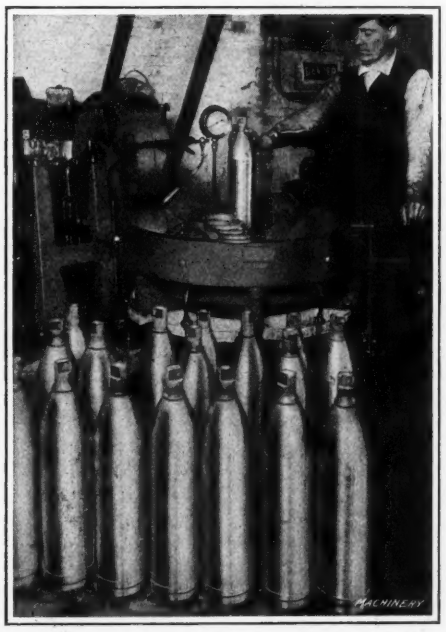


Fig. 86. Pressing on Copper Driving Band in a West Tire Setter Co. Banding Press

Grinding External Diameter

In the grinding operation which follows finish-turning and is illustrated in Fig. 85, about 0.020 to 0.030 inch of material is removed from the diameter of the shell. The machine used is a Norton plain grinder carrying a Norton alundum 20-inch diameter by 2-inch face wheel, grain 46, grade M, rotated at 1275 R. P. M. The grinding is done only on the straight portion, starting at a short distance from the base end, and proceeds straight until the enlargement near the nose is reached. The wheel is then backed away from the work the required distance, and the straight portion finished on the nose to the point where the

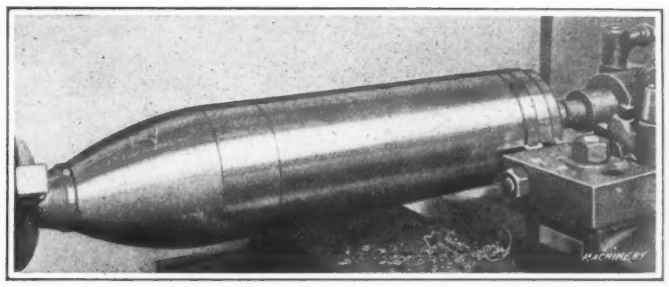


Fig. 87. Turning Copper Driving Band

radius merges. Owing to the length of the work, the traverse method of grinding is used. The wheel is trued up after grinding every three shells. The production is eight shells per hour from each machine.

Pressing On and Turning Copper Bands

When the copper band is of the ring type, the pressing on is done in a West Tire Setter hydraulic banding press as shown in Fig. 86. The inside diameter of this band is slightly larger than the external diameter of the shell, and is located in the correct position by means of the compressing dies, six

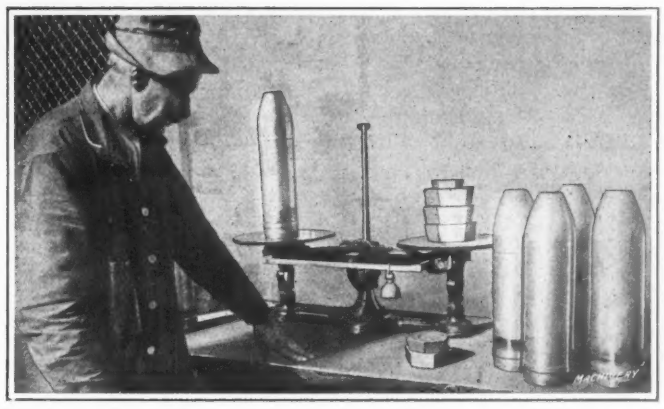


Fig. 88. Weighing French 120-millimeter High-explosive Shell

of which are held in the machine. It requires from two to three squeezes to finish the pressing, and the production is twenty shells per hour. Before pressing on, the copper rings are heated to a dark red, then dipped in water and cooled to the temperature of the surrounding atmosphere. Following the pressing on of the band, the shells are taken to a 16-inch engine lathe, as shown in Fig. 87. The first operation is to take a rough cut over the external diameter of the copper band with a turning tool, after which a form tool is brought into

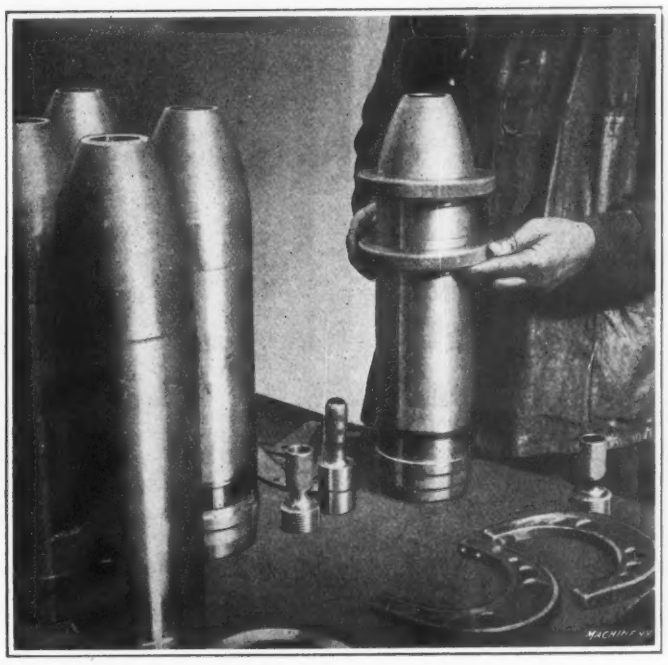


Fig. 89. Gaging External Diameter and Thread in Nose

Fig. 90. Gaging Contour of French 120-millimeter High-explosive Shell

position and finishes the copper band to shape and diameter. The production is twenty per hour.

After turning the copper band, the center projection is cut off from the closed end of the shell. This is done on a Williams Tool Co., cutting-off machine at the rate of twenty-four per hour. The center plug in the open end of the shell is also removed, leaving the shell in a suitable condition for weighing and inspecting.

Inspection

The first inspection is for weight as shown in Fig. 88. The correct weight is 16 kilograms, 750 grams, and the tolerance is ± 200 grams (35 pounds, 6.97 ounces, ± 7.05 ounces.) The first gaging test made is that for "bulge diameter." This test is illustrated in Fig. 89, where it will be seen that two ring gages are used. The diameter over the bulge is 119.6 millimeters plus 0.00 millimeters minus 0.15 millimeter. The "go" size must pass over the bulge, and the "not go" size must stop on it, as shown in the illustration. The next test that is made is over the copper band, and for this, snap gages of the horseshoe type are used.

Fig. 91. Gaging Concentricity of Shell

The limits are 121.5 millimeters plus 0.15, minus 0.00 millimeters. The third test is for over-all length, which is accomplished by means of a gage similar to that illustrated in Fig. 75. With a gage of a similar kind, the thickness of the closed end is measured from the nose. The next test is the diameter across the nose. This is made with a flat gage and the limits are 55 millimeters plus 1.0, minus 0.00 millimeters. The master thread gage is next screwed into the nose to see if the thread is O. K.; after this the plug is also tried for diameter at root of thread. These gages are all shown in Fig. 89. The next test that is made is for the contour. This is accomplished as shown in Fig. 90. A long flat gage that covers the entire length of the shell and also the contour at all points is laid across the shell, as illustrated, and by this means the inspector determines whether the shell has been turned and finished to the correct shape or not. Every point on the shell must check up to the templet. The next test is made with a similar gage and consists in testing the angle at the closed end of the shell, as shown in Fig. 92. The maximum diameter is 118.5 plus 0.25 millimeters, and the minimum diameter is 110.5 millimeters.

Testing for Concentricity

The next important test is for concentricity as illustrated in Fig. 91. A counterweight gage *A* having two arms and counterweighted on one end is fastened to the base end of the shell. The shell rests on hardened strips which are fastened to a cast-iron plate. It is located at right angles to the hardened pieces by pins driven into the plate, then is rolled over and must balance perfectly when the gage is in place. The heavy side of the shell is first found by rotating it on the parallel ways and then the weight is located on the light side. The moment of rotation must equal the amount

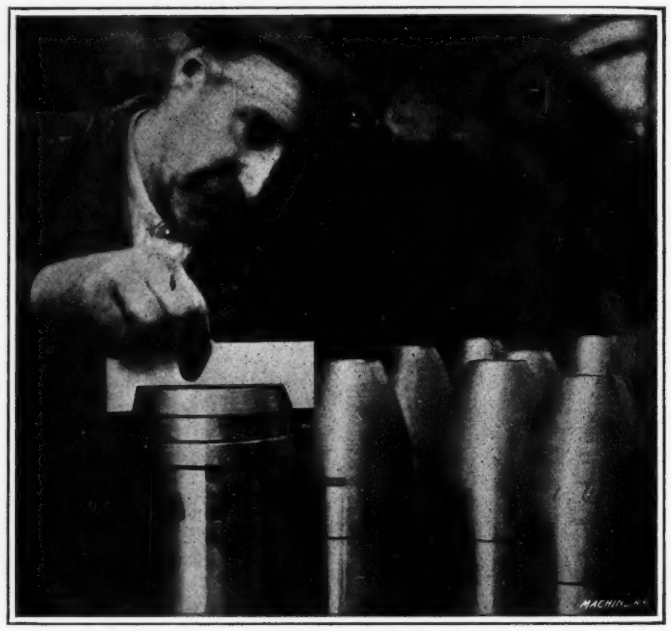


Fig. 92. Gaging Angle on Base End of Shell

of eccentricity from the center of gravity of the shell, which is worked out from the following formula:

$$WS = PR$$

in which W = weight of shell;
P = weight used on stem of gage;
R = distance from center of shell to center of weight P;
S = maximum eccentricity from center of gravity, which on this size of shell is 0.7 millimeter.

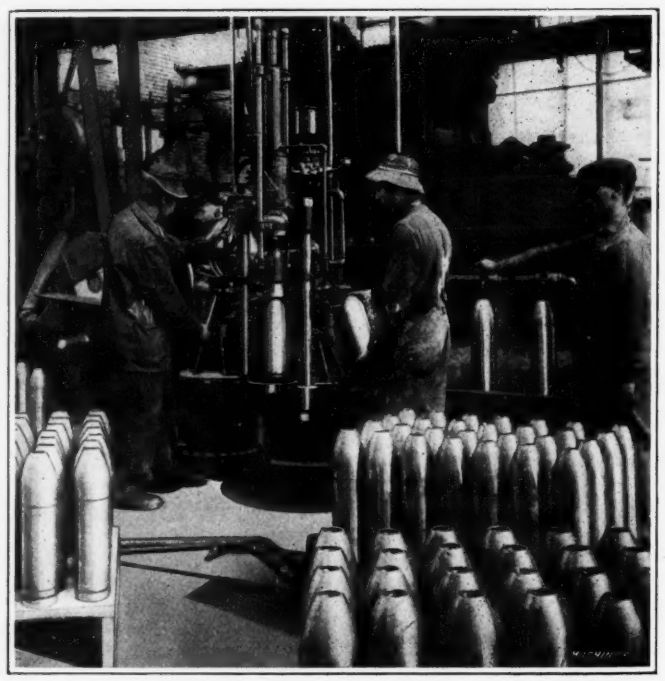


Fig. 93. Testing for Strength in a Metalwood Hydraulic Press

As W, P, and R are known, S may be solved in the equation given. If S is found to be 0.7 millimeter or less, the shell is passed. If, however, S is found to be more than 0.7 millimeter, the eccentricity is too great. P and R may be standardized for the maximum eccentricity, thus avoiding calculating.

Testing French High-explosive Shells for Strength

Every shell after machining and inspection is tested for strength in a hydraulic press of the type shown in Fig. 93. This particular machine is made by the Metalwood Mfg. Co., Detroit, Mich. Previous to testing, the shells are filled with water and placed in the machine shown in the illustration. The pressure is then turned on, which is equal to 650 kilograms per square centimeter or 9500 pounds per square inch. This pressure is maintained on every shell for about ten seconds, and it must show no leaks nor cracks. Following the testing operation, the shells pass through a final inspection, which consists in examining every shell for cracks, etc., and inspection by French officials. One shell in every hundred is given every test by an official. The last operation consists in greasing and packing the shells ready for shipment.

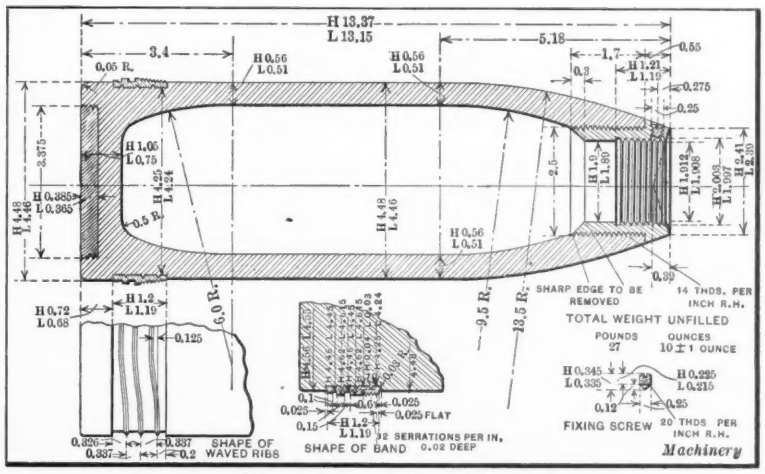


Fig. 94. British 4.5-inch Howitzer High-explosive Shell

MACHINING 4.5-INCH BRITISH HOWITZER HIGH-EXPLOSIVE SHELLS

The British 4.5-inch howitzer high-explosive shell shown in Fig. 94, as previously described, starts with a cast billet about three feet long, which is subsequently cut up into shorter lengths and forged to approximate shape. There are some thirty-two odd machining and inspection operations on this shell, and the average time required to produce one shell complete and ready for shipment is one hour, thirty-six minutes. It should be mentioned, however, that the equipment used for this purpose was not originally laid out for handling this work. In fact, the only special equipment purchased to turn this car shop into a busy shell plant was small tools and a few attachments for engine lathes. This case is only one of the many examples to be found in Canadian plants where standard tools were quickly fitted up for handling shells.

The order in which the various operations are handled is given in the following: The first machining operation consists in cutting off the open end of the shell to the required length. Prior to this, however, the shell is marked off and the amount of material to be removed from each end is indicated. The cutting-off operation, as shown in Fig. 95, is accomplished in an axle lathe which has been fitted up for this work. This axle lathe is of the double-head type, so that two men can work on one machine. The production is 250 in ten hours. The wall of the forging is about 13/16 inch thick, the cut-off tool ⅜ inch wide, and the speed 15 R. P. M.; the cutting tool is fed in by hand.

Facing and Rough-boring

The second operation consists in facing off the closed end in a boring mill where twenty-four of the forgings are held in a fixture. Two tools are used. The depth of cut is ¼ inch and the feed 1/16 inch per revolution. The table of the machine is operated at 120 R. P. M. and the production is about 220 in ten hours.

The third operation consists in rough-boring the interior to 3⅜ inches diameter in a four-spindle rail drill operated by two men, as shown in Fig. 96. The hole is 9⅜ inches deep and is finished in one cut. A cutting lubricant known as "Mystic," made by the Cataract Refining Co., is used to keep the tools cool. The shell being rough-bored is held in a spring collet type of chuck which is attached to a slide that works in guides located on the table. The boring tools are rotated at 50 R. P. M. and the spindle moves down with a speed of about 1/16 R. P. M. The production is 240 in ten hours.

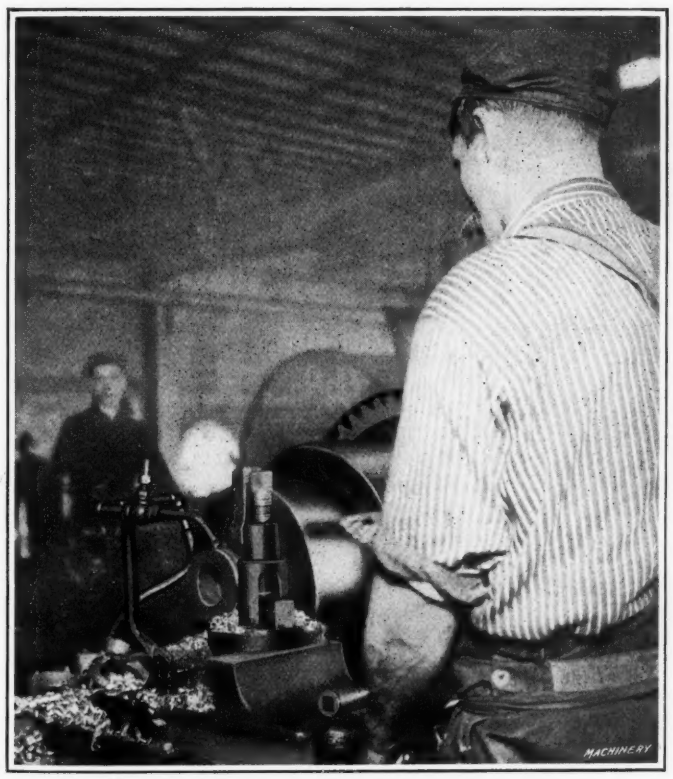


Fig. 95. Cutting off Open End of Forging

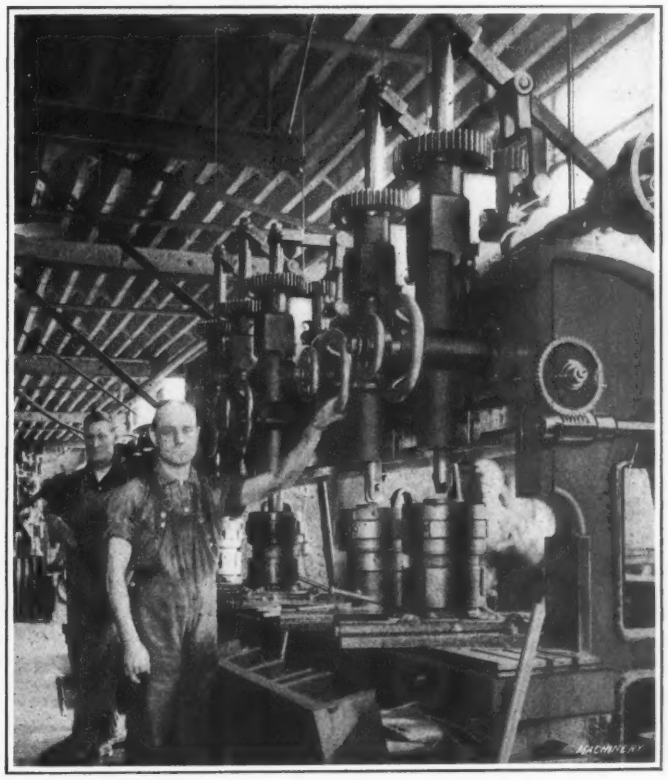


Fig. 96. Boring out Cavity of 4.5-inch Howitzer High-explosive Shells

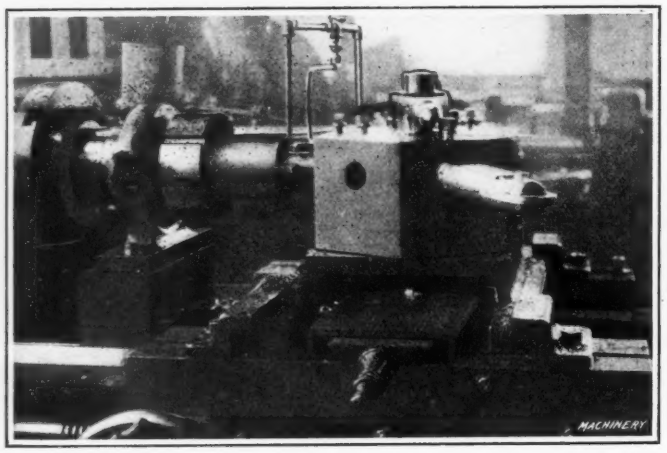


Fig. 97. Finish-boring, reaming and facing 4.5-inch Howitzer High-explosive Shell

The fourth operation consists in centering the base end in an 18-inch engine lathe. The forging is held on an expanding mandrel and the center hole in the base end is first drilled and then centered with a centering tool. The production is 400 in ten hours.

Rough-turning

The fifth operation is rough-turning in an axle lathe. The shell again is held on an expanding mandrel and is turned up for a distance of 9¼ inches from the base end. The feed is 3/32 inch per revolution and the depth of cut is 7/32 inch. The speed of the work is 50 R. P. M. The production is 140 in ten hours.

Spot-drilling, Bottoming and Finish-boring

The sixth operation consists in spot-drilling on the inside with an end-cutter on a 28-inch upright drilling machine. The work is held in a collet chuck and about ¼ inch of metal is removed. The spot-drilling tool is rotated at 140 R. P. M., and is operated by hand feed. The production is 300 in ten hours. The seventh operation consists in hogging out the pocket at the bottom with a form cutter, held in a boring-bar in a wheel boring lathe of the vertical type. This tool is rotated at 48 R. P. M. and just cuts at the bottom; it is operated by hand feed. For this operation the forging is held in an expanding collet chuck and the production is sixteen pieces per hour.

The eighth operation consists in chamfering on a wheel boring lathe with a tool that chamfers the inside of the shell at the mouth only. This tool is rotated at 48 R. P. M. and chamfers for a distance of about 1½ inch down into the shell, enlarging the shell from 3⅜ to 4 3/16 inches. The ninth operation, as shown in Fig. 97, consists in finish-boring the inside of the shell and finish-chamfering the mouth. The first operation is to bore and face with an end facing tool that is located from the bottom; second, finish the pocket at the bottom; and third, chamfer. The machine used is a Bertram 26-inch engine lathe, provided with a turret. The shell is held in an expanding chuck and rotated at 80 R. P. M. The cuts vary from 1/32 inch to just cleaning up, and the production is eighty in ten hours.

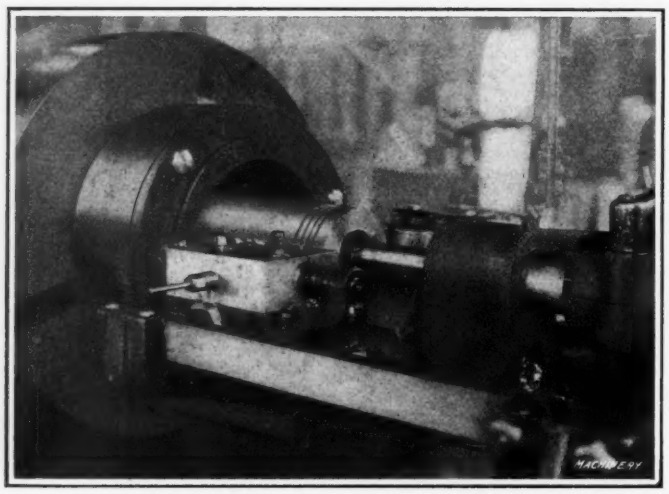


Fig. 98. Waving and under-cutting Band Grooves

Grooving and Waving

The tenth operation is finishing the nose on the outside diameter with two tools. The first takes a straight roughing cut, the second turns the radius, and a third tool held in the same toolpost finish-chamfers the end. The machine used is a New Haven 24-inch engine lathe. The center on the tailstock is brought in to support the work, which is also held in a three-jawed chuck. The work rotates at 60 R. P. M. and the production is 220 in ten hours. The eleventh operation consists in taking a finishing cut over the base, roughing out the band groove, and finishing the external diameter back of the band groove, on a 24-inch New Haven engine lathe. The production is twelve per hour. The work is rotated at 60 R. P. M., and one turner and one form tool are used.

The twelfth operation is waving and under-cutting in a New Haven 24-inch engine lathe, to which has been applied a Bertram waving attachment, as shown in Fig. 98. The work is held in a chuck of the three-jaw type and is supported at the opposite end by the tailstock center. The waving tools are operated by a cam on the face of the chuck. The work is rotated at 40 R. P. M. and the production is twenty-five per hour.

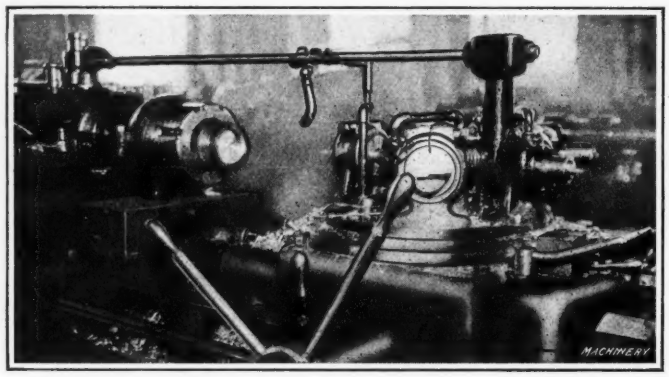


Fig. 99. Boring out Closed End of Shell for Gas Plug and threading

Nosing-in, Boring and Threading Nose

The thirteenth operation is nosing-in. This is done in a Williams & White bulldozer. The shell is heated in a furnace to a white heat—about 1800 to 1900 degrees F.—and is nosed-in in one blow. It requires three men to handle this operation; one looks after the furnace and two after the machine. The production is 400 in twelve hours. After cooling, the shell is brought back to the machining department where the fourteenth operation is performed. This consists in boring out the closed end of the shell for the gas plug and threading on a Jones & Lamson single-spindle flat turret lathe, as shown in Fig. 99. The operations are: first, drill 1⅜-inch diameter; second, hog out with a flat cutter; third, under-cut and face with a combination under-cutting and facing tool; and fourth, thread with a Jones & Lamson regular chasing attachment. The work for all operations except threading is operated at 30 surface feet per minute, and the production is ten per hour.

The fifteenth operation consists in machining the nose on a 20-inch Reed engine lathe, provided with a turret attachment, shown in Fig. 100. The operations are: first, bore, taking a 1/16-inch cut at a speed of 50 R. P. M., and face off to length; second, rough out inside radius with a boring tool, feeding by hand; third, finish inside radius to shape with a form cutter; and fourth, tap for a distance of 2 inches with a Murchey collapsible tap. The production is nine and one-half per hour.

Finish-turning

For the sixteenth operation a center plug is inserted in the open end of the shell. The external diameter is then turned all over in an 18-inch Canadian Machinery Corporation lathe.

As shown in Fig. 101, two cutters, which are held in the tool-post, are used for finishing. The cut is about 3/64 inch deep, and the operation of the tool-slide is controlled by a forming bar at the rear. The feed of the tools is 1/32 inch per revolution; and the speed, 100 R. P. M. The production is nine per hour.

Miscellaneous Operations

The seventeenth operation is sandblasting the inside with an air nozzle inserted in the shell; production, about 200 in ten hours. The eighteenth operation is preliminary inspection. The nineteenth is to screw in the base plug, and at the same time wrench off the projection with a heavy wrench. The twentieth operation is to face off the plug and round the edges of the base on a Canadian Machinery Corporation 18-inch engine lathe. The operations are: first, take a roughing cut across the base; second, roll in plate with a plain roller; and third, take a finishing cut across the base. For these operations the feed is by hand and the cuts vary in depth from 1/16 to 3/16 inch. The speed of the work is 120 R. P. M., and the production is fifteen per hour.

The twenty-first operation is stamping with hand stamps, the work being held in a fixture while this operation is being performed. Sixteen stamps are necessary and the production is 295 shells in ten hours. The twenty-second operation is re-tapping the hole in the nose of the shell with a Murchey tap, the shell being held in an Acme single-head threading machine, carrying a chuck instead of a die-head. The production is twenty-five per hour.

The twenty-third operation is screwing in the brass nose bushing by hand, holding the shell in a fixture. The twenty-

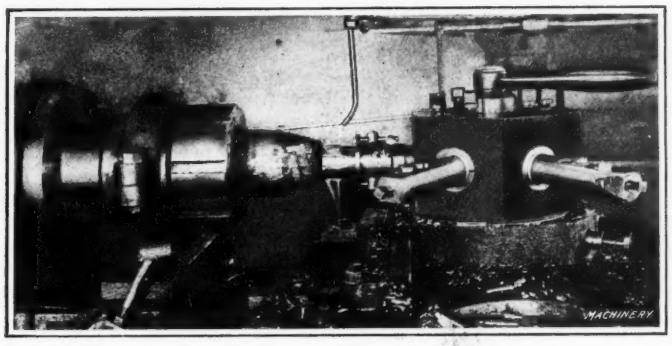


Fig. 100. Boring, facing and threading Nose End of Shell

fourth consists in turning the brass socket in a 20-inch McDougal engine lathe, one cutting tool being used. The production is twenty per hour. The twenty-fifth operation is cleaning out the shell with benzine and then varnishing it with a brush. The shell is laid down on the bench, rolled back and forth by the operator, and the interior varnished with a brush that is shaped like a toothbrush but is much larger. Two men are employed for this operation and the production is 400 in ten hours. The twenty-sixth operation is baking the varnish on the shell in an oven, which is heated to 300 degrees F. This oven is kept at a constant temperature and the shells are left in for eight hours. They are then taken out and left to cool in the air. The furnace holds 240 shells, so that the production is 240 in eight hours.

Pressing on and Turning Copper Bands

The twenty-seventh operation is pressing on the copper band, which is done in a special banding machine having four hydraulic cylinders. The production is 225 in ten hours. Turning the copper band is the twenty-eighth operation, and this is done in a 22-inch Walcott & Wood engine lathe, equipped with a Lymburner Ltd. band turning attachment, as shown in Fig. 102. This attachment carries two forming tools, one on the front and one on the rear of the cross-slide. The operations performed are: rough-turn band with a tool on the top of the slide, operated by a turnstile at the front; rough-form band to shape with a form tool; and finish band with a forming tool held on a special attachment at the rear of the machine and operated by a separate handle. The work is rotated at 250 R. P. M. and the production is twenty-five per hour.

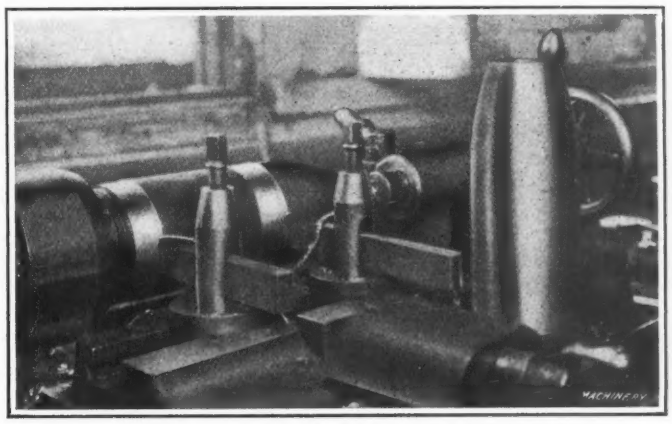


Fig. 101. Turning External Diameter to Size and Shape

The twenty-ninth operation is the final inspection. The thirtieth, applying the first coat of paint, the base of which is white lead; the thirty-first, applying the second coat of yellow paint. After drying, the shells are again inspected and packed ready for shipment, the plug, of course, being screwed into the nose to prevent foreign matter from getting into the cavity of the shell, and also to protect the threads in the nose from bruises. The plug is retained in the shell until it is removed for loading; it is then replaced and not removed again until the shell reaches the field of operations, where it is taken out and the detonating fuse substituted.

MACHINING 9.2-INCH BRITISH HOWITZER HIGH-EXPLOSIVE SHELLS

Starting with the finished forging, which is made with a closed-in nose, and has been carefully annealed, the first machining operation on the 9.2 British howitzer high-explosive shell shown in Fig. 103 consists in drilling a two-inch hole through the nose and in facing off the nose end of the shell until the required length is obtained. These operations are performed on a six-foot radial drilling machine as shown in Fig. 104, using a two-station jig that enables one side to be loaded while the machining operations are being performed on a forging located on the other side. The jig *A* is in the form of an angle-plate, and the radial arm of the machine is moved to bring the tool in line with the work. The drilling is done at a cutting speed of 60 to 65 feet per minute with a down feed of 1/64 inch per revolution. The production is five and one-half shells per hour, one man operating the machine.

Cutting-off and Rough-turning Operations

The next operation is cutting off the open end, which is done on a 24-inch Pond lathe. The forging is held in a "pot-chuck" (see Fig. 106) and is gaged from the end just machined. The surplus stock on the open end is cut off by means of a special carriage carrying two cutting-off tools, and oper-

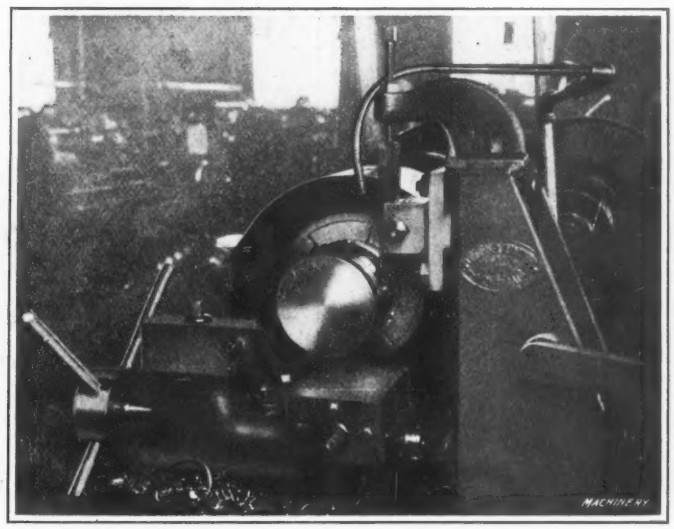


Fig. 102. Turning Copper Driving Band

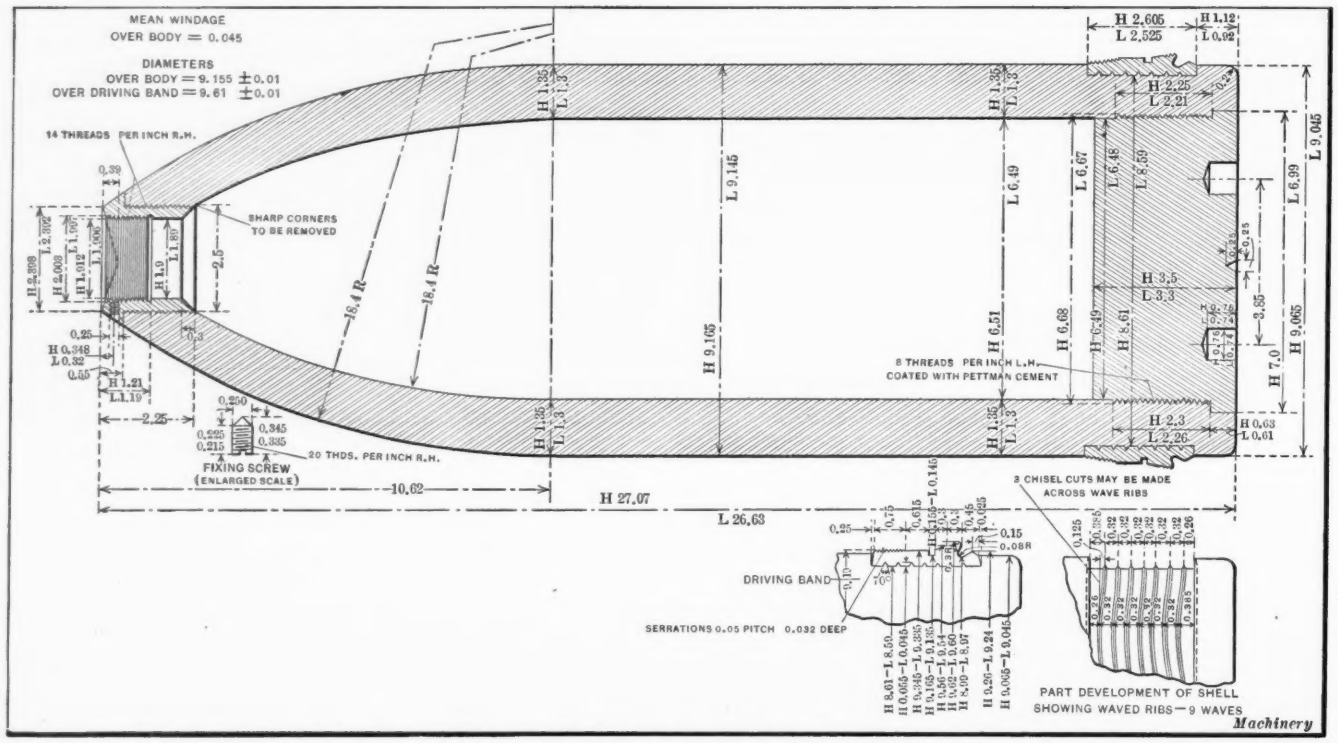


Fig. 103. British 9.2-inch Howitzer High-explosive Shell

ated by right- and left-hand screws, so that both tools are at work at the same time. The blades of the cutting-off tool are ⅜ inch wide, and the surface speed of the work is from 70 to 80 feet per minute. One man operates two machines and cuts off seven shells per hour.

After cutting off, the straight portion of the shell is rough-turned. For this operation the shell is held on a mandrel that has two sets of expanding plungers, and the work is done on a 24-inch Pond lathe. Two cutting tools are used that remove a total of ¾ inch on the diameter in one cut. Each tool removes ⅜ inch, and works at a cutting speed of 70 to 80 surface feet per minute. As the forgings vary somewhat, it is often necessary to take two cuts to finish. The longitudinal feed is ⅛ inch per revolution of the work. At this setting, the nose of the shell is not touched, and the next operation is the roughing of the nose to the required radius. This is handled on a 24-inch Pond lathe as shown in Fig. 105. The shell is gripped from the internal diameter by expanding mandrel *A*, fastened to the faceplate as shown.

Two cutting tools are used which are guided in the correct path by a simple but satisfactory device. This radius device comprises a special carriage *B* that is carried on a bracket *C* bolted to the bed at the rear of the lathe. Located on carriage *B* is a stationary slide *D* to which is bolted link *E* that serves to connect cross-slide *F* with the rear carriage. The cross-feed screw ordinarily used is removed so that the motion of slide *F* in a radial direction is controlled by link *E*. In operation, as the front carriage is fed toward the faceplate, link *E* forces cross-slide *F* back and thus guides the cutting tools in a curved path. The correct starting and finishing points of the radius on the shell are obtained by adjusting screw *G*. The production for rough-turning the straight diameter and nose is one shell per hour.

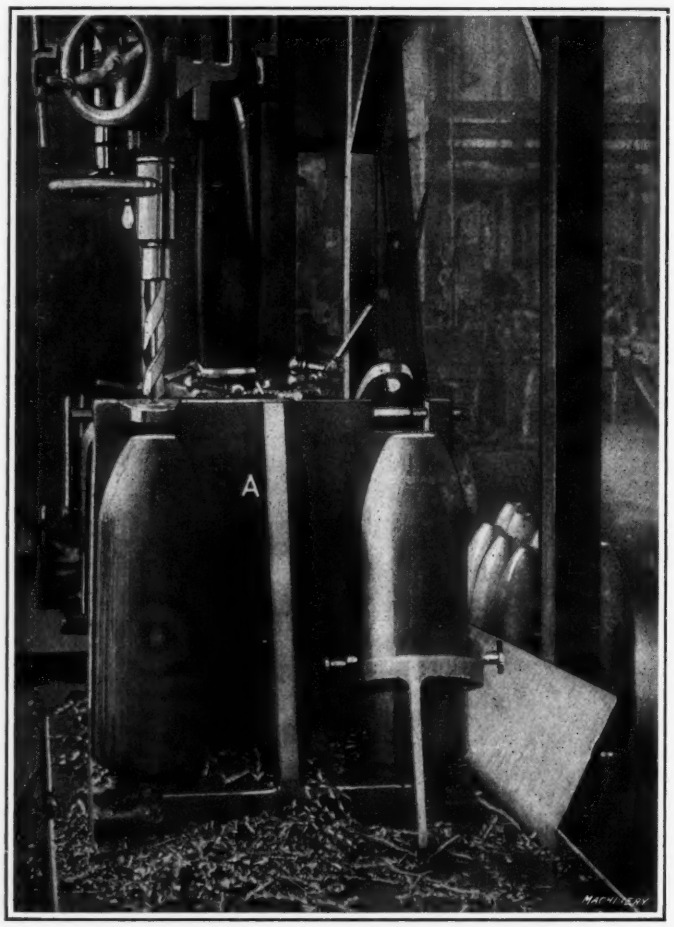


Fig. 104. First Machining Operation on 9.2 British High-explosive Shell Forging—drilling Hole in Nose and facing

Boring, Counterboring, Facing and Threading Operations

The next operation is boring, which is performed on a 36-inch Pond heavy-duty lathe provided with a rack tailstock, as shown in Fig. 106. For machining, the shell is held in a "pot-chuck" clamped to the faceplate and is additionally supported by a steadyrest as shown. The interior of this chuck is made an easy fit for the shell, the latter being held by contracting the chuck, which is split, by clamping bolts as shown. Two three-tooth boring reamers are used, one roughing and one finishing, which remove about ½ inch from the diameter between them. The roughing reamer is provided with high-speed steel blades which are serrated to break up the chip, whereas the finishing reamer is provided with smooth blades of high-speed steel. The cutting speed of the reamers is 74 to 78 surface feet per minute. The longitudinal feed is very coarse (½ inch per revolution) until the radius is reached, where it is reduced to 1/32 inch per revolution. The production is one shell per hour.

Following the operation just described, a series of operations is performed on the nose of the shell on a 24-inch Pond lathe provided with a four-sided turret. The shell is held in a "pot-chuck" in a

similar manner to that just described, but of course the nose instead of the base end projects. The operations are: rough- and finish-bore opening, rough-face end, tap and finish-face end. The finishing cuts are taken at an average speed of 120 surface feet per minute and the feed is 1/32 inch per revolution. The production is two shells per hour.

The reverse end of the shell is now machined, and as was the case in the previous operation, is held in a "pot-chuck." The work is done on a 24-inch Pond lathe provided with a four-sided turret. The operations are: face off base end, bore and counterbore, and chase thread for base plug. The cutting speeds are 120 surface feet, feeds 1/32 inch per revolution, and production one shell per hour.

Finish-turning, Grooving, Waving and Assembling Base Plug

The finish-turning on the external diameter comes next, and this is done on a 24-inch Pond lathe provided with a former-plate, somewhat similar in design to an ordinary taper-

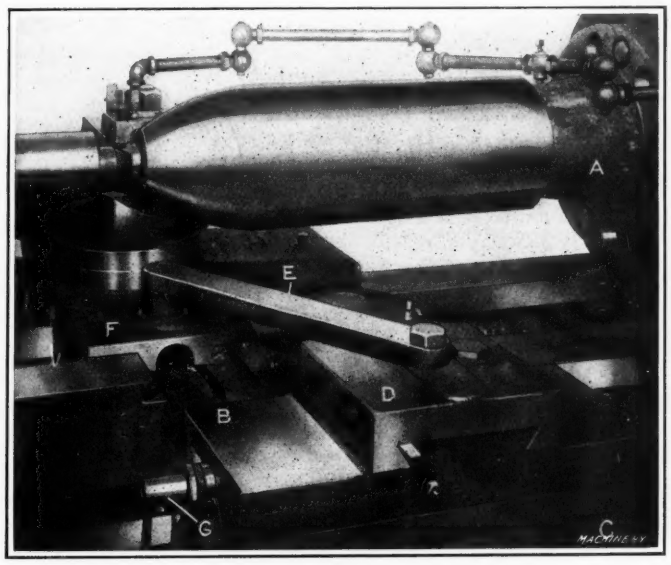


Fig. 105. Turning Radius on Nose on a 24-inch Engine Lathe

turning attachment. One cutting tool is used and one cut finishes the work. The speed is 120 surface feet, and the feed 1/32 inch per revolution. The production is two shells in three hours.

Following this operation the shells are taken to the 24-inch Pond lathe shown in Fig. 107, where the band groove is cut and the wave ribs produced. The shell is held on a special mandrel *A* (see Fig. 108 for details of construction) which is driven by a special faceplate *B*, Fig. 107. This faceplate carries cam *C* used in oscillating the rear waving slide *D* as described later. The lathe carriage is provided with a turret toolpost *E* carrying four tools that perform the following operations: Tools *F* are used to neck at the limits of the band groove; tool *G* roughs out the groove to the top of the ribs; tool *H*

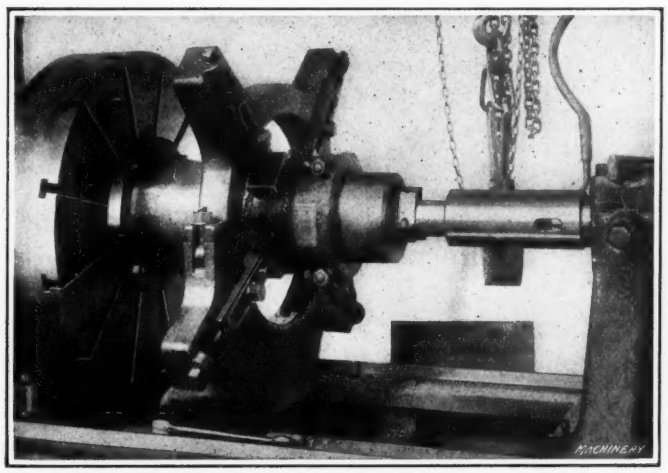


Fig. 106. Rough- and finish-boring Internal Diameter on a 36-inch Engine Lathe

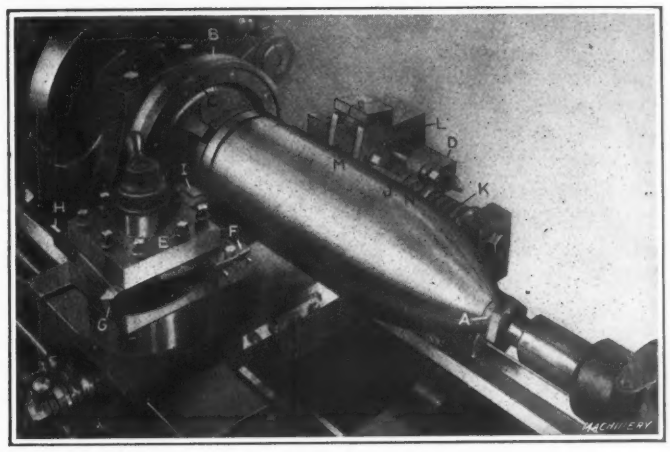


Fig. 107. Set-up on a 24-inch Engine Lathe for machining Band Groove and cutting Wave Ribs

under-cuts the edges of the groove; and tool *I* roughs out between the wave ribs. The wave ribs are produced by the special fixture *D* held on the rear of the carriage. This comprises a slide *J* which is oscillated by cam *C* against the tension of spring *K*, and carries a tool-holder *L* that holds the waving tool *M*. Tool-holder *L* is adjusted for position by screw *N*. This fixture is operated by bringing the cross-slide forward and moving the carriage over, until a roll (not shown) engages with cam *C* which imparts the required oscillating movement to slide *J*. The band grooves are cut and ribbed at the rate of eighteen shells in ten hours. Putting in the base plug and nose bushing is the next step, and this is done by hand. Each plug is carefully fitted and cleaned, and is left partially screwed in place until such time as the loading of the shell is finished.

Banding and Band-turning Operations

The pressing on of the copper driving band is performed in a Dudgeon hydraulic banding press. The copper bands are heated to a bright red in a "Best" oil furnace, and when they have attained the correct temperature they are quickly removed and placed in the banding press. The shell is now placed in the press, the band being slipped over it and located by the dies in the correct relation to the groove. The press

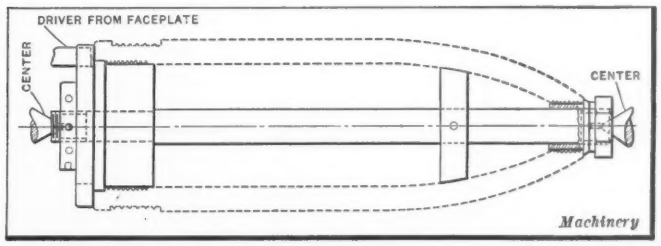


Fig. 108. Diagram showing Details of Construction of Fixture used for holding Shell when performing Operation shown in Fig. 107

is now operated, whereupon six dies are forced in radially and compress the band into the groove. After the first squeeze, the shell is turned around 30 degrees and given another squeeze. The production on this operation is about twenty shells per hour.

The copper band is turned on the Pond 24-inch lathe shown in Fig. 109. Here it is supported and driven from one end by a special driver *A*, Fig. 110, and is supported on the nose end by a revolving center *B*. The cross-slide carries a turret toolpost *A*, Fig. 109, holding four tools, which, in conjunction with a forming tool on the rear of the slide, rough- and finish-turn the band to shape. The production is three shells per hour.

Weighing, Cleaning, Varnishing, etc.

Upon the completion of the machining operations, the shells are weighed, the limit in weight being 10 ounces either way from the standard, which is 252 pounds. Working from the nose end, the shell is now washed out with soda water and then dried, after which a coating of Copal varnish is sprayed in with a "Buffalo" air spray brush. The shell is swabbed outside, while hot, with a light machine oil and then baked for eight hours at a temperature of 300 degrees F.

Considering the weight of these shells, it is interesting to follow the way in which they are handled. A continuous track runs down the aisle of the shop between two rows of machines along which the shells are kept moving. Shells of this size are too heavy to handle by hand, so light air hoists are located over each machine to facilitate handling. Stamping, inspecting, etc. finish the operations on the shell, after which it is ready for packing and boxing.

ROUGHING OUT HIGH-EXPLOSIVE SHELLS IN HIGH-POWER DRILLING MACHINES

British 18-pound high-explosive shells are made from bar stock, as has been previously described, and the usual method is to rough out the hole in a high-power drilling machine. Figs. 111 and 113 show an efficient method of accomplishing this operation. The machines used are Baker Nos. 310 and 315 vertical high-power drilling machines (the latter size being of the extra-heavy pattern) equipped with a special

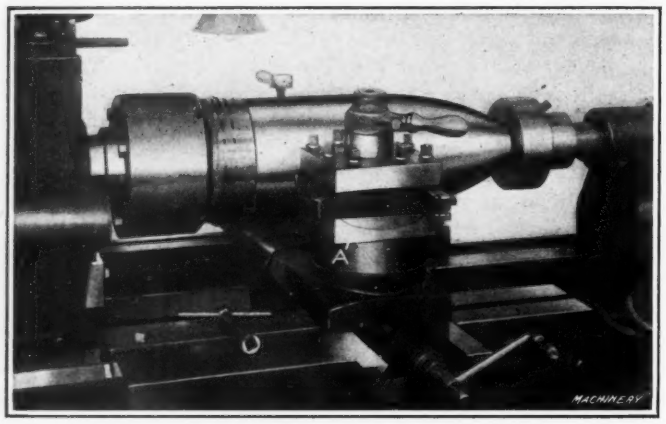


Fig. 109. Set-up for turning Copper Band to Shape on a 24-inch Engine Lathe

fixture *a* clamped to the table. This fixture is provided with four tool-steel holding jaws that support the bar in a vertical position, and are operated by right- and left-hand screws by means of a turnstile *b*. At *A* is shown the first rough-drilling operation, which is accomplished by means of a 1 13/16-inch diameter high-speed drill driven at 175 R. P. M. with a down feed of 0.020 inch per revolution. The drilling time is about three minutes per shell. *B* shows the second operation which consists in removing the vee left by the point of the drill, and rounding the bottom. *C* shows the final reaming operation; and *D* illustrates the special tool used for machining the exterior of the nose of the shell. The tool used for this purpose is designed along the principles of a hollow-mill carrying one inserted high-speed steel blade. In this set-up

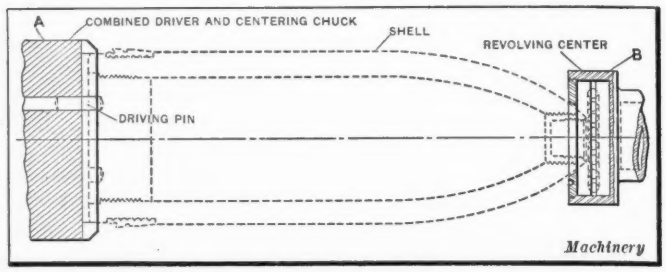


Fig. 110. Diagram showing Method of holding and driving Shell when performing Operation shown in Fig. 109

it will be noticed that a special bushed bracket is fastened to the top of the fixture, to support the large nose turning tool.

Previous to cutting the thread in the nose of the shell, it is necessary to recess it at the point where the thread terminates. This is accomplished by a recessing tool of the construction shown in Fig. 112. Referring to this illustration, it will be noticed that the tool consists of a holder *A* provided with a tang fitting into the drilling machine spindle. This carries sleeve *B* that is operated upon by a spring *C*, the latter lying in between the recessed shoulder of the sleeve and a washer *D* that is pinned to bar *A*. The recessing tool proper *E* is carried in an elongated slot in the lower end of bar *A* and is operated by means of an angular slot in the bar through a pin driven through the recessing tool. In operation, the drilling machine spindle is brought down until sleeve *B* contacts with the nose of the shell, whereupon further downward movement of the spindle compresses spring *C* and at the same time forces out the recessing tool *E*, cutting the annular groove in the interior of the nose. The last operation, as performed in the drilling machine, consists in threading, and it is accomplished with a collapsible tap as illustrated at *F* in Fig. 113.

The layout advocated by Baker Bros. for this work is a gang of six machines, consisting of two No. 315 extra-heavy pattern machines for the drilling and nose-turning operations, and four No. 310 machines for the bottoming, reaming, counterboring, facing, under-cutting and tapping operations. This gang of six machines gives a production of eight shells per hour, and leaves them ready for the lathe turning operations.

SURFACING GAS PLUGS ON BESLY RING WHEEL GRINDERS

The gas plug used in the base end of British high-explosive shells is made from a forging and must be faced on the end that is next to the shell. Several methods are used in surfacing the inner face of this plug, and a very satisfactory one is to grind it on a Besly No. 14-16 wet ring-wheel grinder, shown in Fig. 114, which is equipped with a special rotary chuck shown in detail in Fig. 115. Fig. 114 shows two operators

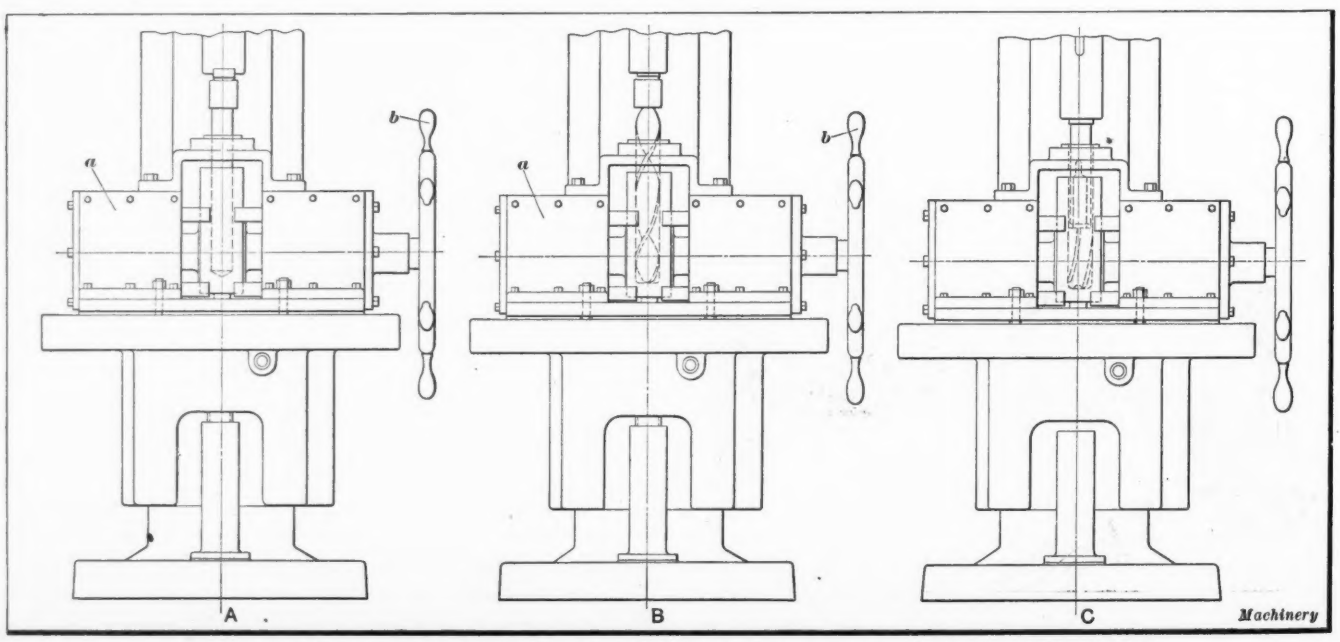


Fig. 111. Preliminary Operations in roughing out a British High-explosive Shell on a High-power Drilling Machine

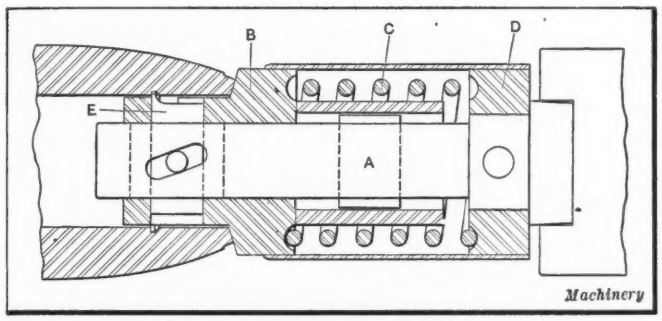


Fig. 112. Special Recessing Tool used for performing Operation E shown in Fig. 113

at work grinding the face of gas plugs. The jaws of this rotary chuck are threaded to grip the threaded body of the plug when the latter is machined, and consequently the base is finished true with the threaded body of the plug. For grinding, a cylinder type of wheel is used that is held in the standard Besly pressed-steel ring-wheel chuck. The wheel is about 16 inches diameter, 3 inches face. Gas plugs for British 4.5-inch high-explosive shells can be turned out from the rough at the rate of sixty to eighty per hour for one operator by this machine. The machine, of course, is double-ended, so that two operators can work on one machine at the same time. The action of the grinding wheel rotates the work while grinding, producing the desired accuracy.

The Besly No. 14-16-inch L type wet-wheel grinder shown in Fig. 114 is also used for grinding off the projections on gas plugs and facing the base end. On the 18-pound British high-explosive shell, the projection on the end of the gas plug is about ¾ inch long and ⅞ inch diameter, of square section. (In some cases this section is made triangular in shape.) On the Besly No. 14-16-inch grinder, twenty-five shells can be ground per hour. The grinding machine, of course, accommodates two operators, giving a combined production of fifty shells per hour per machine. At the same time that the projection is removed from the gas plug, the surface of the gas plug is also ground, 1/32 inch of material being removed. The diameter of the plug on the 18-pound shell is about 2¼ inches (see Fig. 116). Where the projection on the gas plug is triangular in shape, the production can be greatly increased because this projection is only ⅜ instead of ¾ inch high. On the type of gas plug here described, the production is about 100 shells per hour per operator, or 200 shells per machine. Fig. 116 shows a British high-explosive shell that has been finished off on the base on the Besly grinder illustrated in Fig. 114 and also the two types of gas plugs referred to. The one shown at *A* is of triangular section, whereas the one shown at *B* is of square section with a hole in the center.

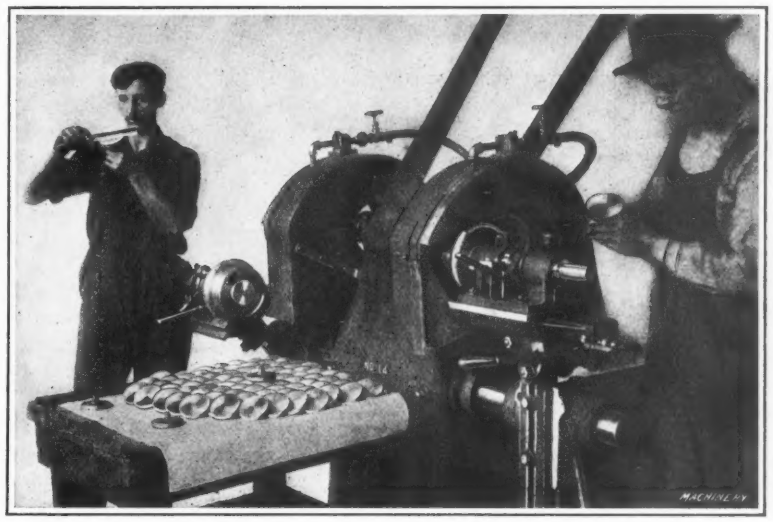


Fig. 114. Surfacing High-explosive Shell Gas Plugs on Besly No. 14-16-inch L "Wet" Ring Wheel Grinder

TESTING HARDNESS OF HIGH-EXPLOSIVE SHELLS

When orders for high-explosive and shrapnel shells were first placed in this country and Canada, considerable trouble was experienced in getting shells to pass the government inspectors. While a large number of concerns were successful in getting the shells finished to the required dimensions, many experienced trouble in heat-treating shrapnel shells and attaining the desired physical properties. The government inspectors finally decided on using testing apparatus which could be applied to every shell after heat-treatment and thus check up the tensile strength of the shells. There are two well-known methods of testing the hardness of metals, namely, the scleroscope shown in Fig. 117 and the Brinell instrument shown in Fig. 81. Of these two, the Brinell is the older. The British government has been using both of these instruments for some time, but in general, on shell work the Shore method has been adopted because of the rapidity with which the test could be made. Also it did not injure the parts and could be used on hardened metal, for which the Brinell method is not as adaptable.

Extensive tests have shown that there is very little difference in the results obtained with the Brinell and the Shore method. What little difference there is, is due principally to the Brinell indenting pressure, which is applied slowly and then left on for fifteen seconds or more. The time taken and the extreme stress imposed, causes undue variation depending

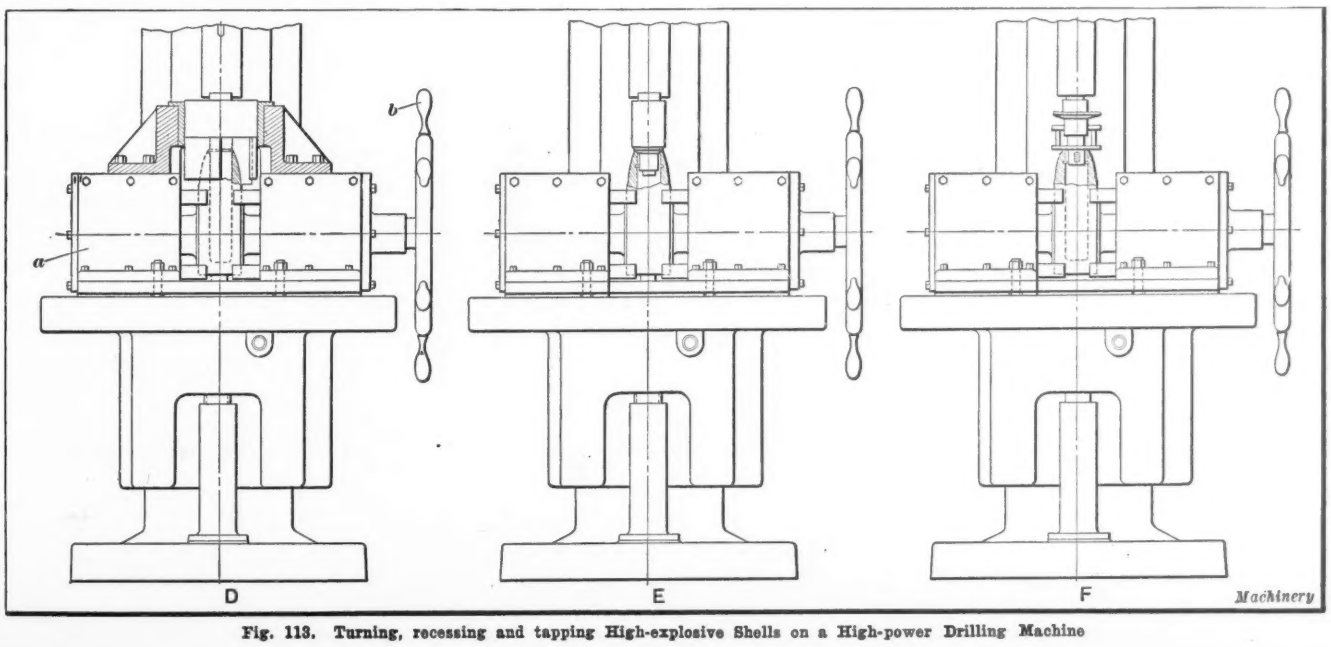


Fig. 113. Turning, recessing and tapping High-explosive Shells on a High-power Drilling Machine

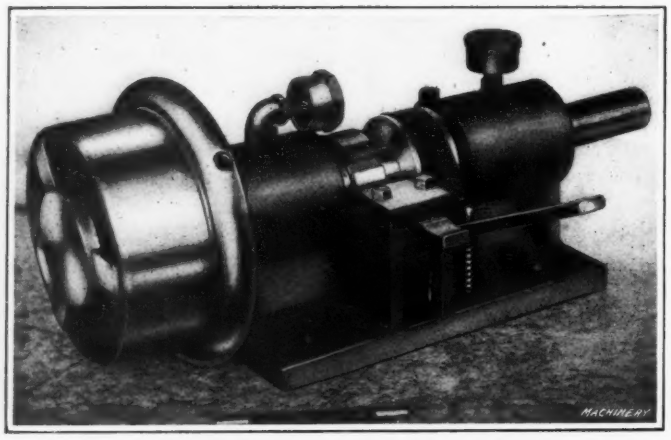


Fig. 115. Special Rotary Chuck used on Besly Disk Grinder for surfacing Gas Plugs

on the ductility of the metal. In fact, the Brinell reading is so influenced by ductility that claims have been made that it shows the ultimate strength; as a matter of fact, however,

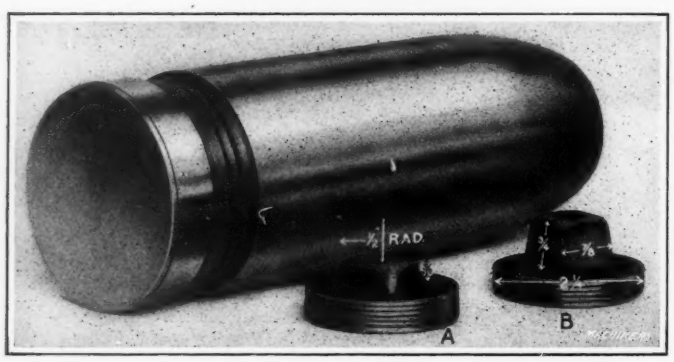


Fig. 116. Three-inch High-explosive Shell, showing Finish left by Besly Grinder; also Two Types of Gas Plugs

the reading taken by the Brinell method, is an expression of the elastic limit. The scleroscope, on the other hand, imposes a limited stress on the metal, and this is done instantaneously and causes only slight mechanical super-hardening, so it logically preserves the original values and thus serves to indicate the elastic limit without undue variation leaning toward the ultimate strength. It is for this reason that exact comparison between the two tests can only be made on one kind of metal at a time or in a given state of heat-treatment. On heat-treated steel used in shrapnel and high-explosive shells, the ratio is given by Shore as 6.4, meaning that if the scleroscope shows, for example, 50 hard, this multiplied by 6.4 would give the Brinell hardness, or a value of 320.

The method of testing shrapnel shells has previously been described in the April number of MACHINERY, so that attention will be directed here to the testing of high-explosive shells. In the first place, all high-explosive shells are not heat-treated, those used by the British government being a good example. These are made from a special tough alloy steel, the required physical properties of which are contained in the "raw" steel, so that it does not require to be heat-treated after machining. The high-explosive shells used by the French and Russian governments, however, are heat-treated either previous to or following the first series of machining operations. The specifications on the British high-explosive shell are:

Constituents	Per Cent Min.	Max.
Carbon	...	0.55
Nickel	....	0.50
Silicon	....	0.30
Manganese	0.4	1.00
Sulphur	....	0.04
Phosphorus	....	0.04
Copper	....	0.10

This steel in an untreated condition must give a yield point of 19 tons and a breaking strength of 35 to 49 tons, with an elongation of 17 to 20 per cent. The method of using the scleroscope on the British high-explosive shell is to test each bar of stock after the first external cut or before any of the important machining operations have been performed on it, so that any defects in the material can be discovered before it has gone too far.

The French high-explosive shell is made from steel containing a lower percentage of carbon and no nickel. The specifications on the French high-explosive shell are:

Constituents	Per Cent Min.	Max.
Carbon	0.30	....
Silicon	0.18	....
Manganese	0.50	0.80
Phosphorus	0.04	0.07
Sulphur	....	0.05

After hardening and tempering, a tensile strength of 125,170 pounds per square inch is required with an 18.3 per cent elongation. The elastic limit would be about 80,000 to 120,000 pounds per square inch, or as shown in Fig. 117, 43 to 52 hardness on the scleroscope and 275 to 333 on the Brinell instrument, respectively. The elongation and ultimate strength are determined by testing a shell, selected at random, to destruction.

The Russian high-explosive shell has a chemical composition somewhat similar to the French. It is hardened and tempered to show a physical property giving an elastic limit of not less than 62,000 pounds per square inch, a tensile strength of 118,000 pounds per square inch, and an elongation of 10 per cent. These properties in a steel of the chemical constituents given above would give a scleroscope hardness of 40 to 45 when heat-treated.

GRINDING HIGH-EXPLOSIVE SHELLS

The British high-explosive shell is not heat-treated, and consequently many manufacturers are finishing the external diameter to size and shape by turning; others, however, are using the grinding method. The turning method cannot be used as successfully on the Russian or French shells as on the British shells, because the former are heat-treated. The practice followed in grinding high-explosive shells differs in various plants. The diagrams Figs. 119 and 120 show several methods that are employed in grinding high-explosive shells on the Ford-Smith heavy-type, plain grinder shown in Fig. 118. Considerable improvements have been made in grinding high-explosive shells, especially as regards keeping the face

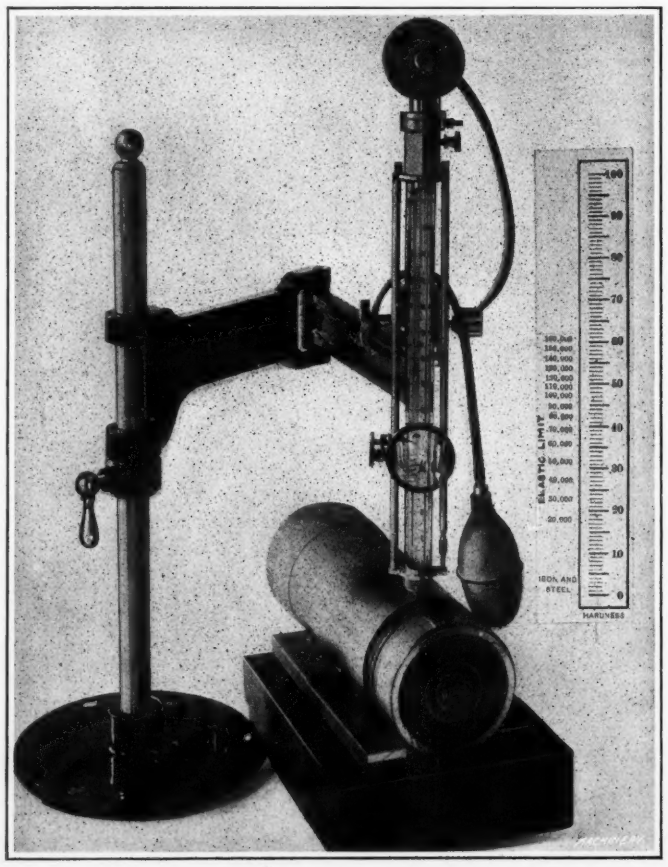


Fig. 117. Testing Hardness of High-explosive Shells with Scleroscope

of the wheel true. When this method was first adopted it was thought that it would be necessary to true up the entire face of the wheel with a diamond truing device after grinding a comparatively small number of shells. This, however, has not proved to be the case, and the truing up of the face of the wheel can be done quickly by hand by the use of a carborundum stick. A comparatively large number of shells can be turned out with one truing of the wheel, and on the Ford-Smith machine a special wheel-truing device, as illustrated in Fig. 121, is used. This will be described later.

The diagram Fig. 119 illustrates three different methods of grinding high-explosive shells of the 18-pound size. That shown at *A* consists in finishing the nose of the shell on the lathe, and then grinding the external diameter from the band groove to the radius, with a two-inch face wheel, by traversing the work past the wheel. In the method shown

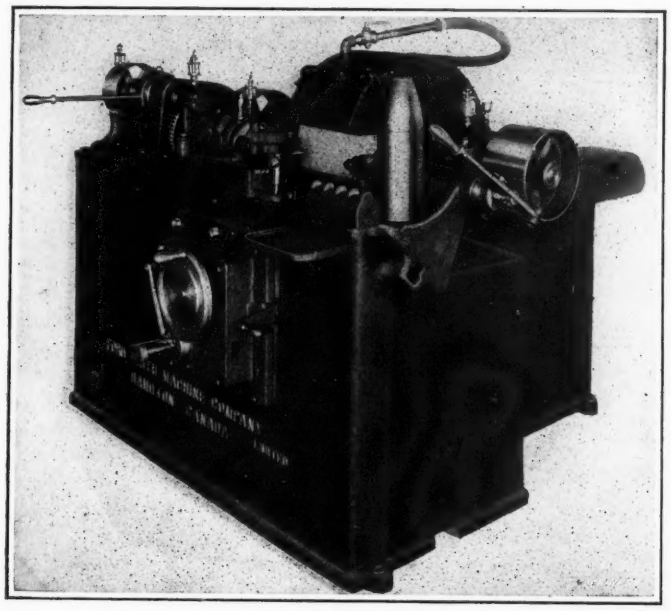


Fig. 118. Ford-Smith Plain Wide Wheel Shell Grinder

at *B* a six-inch face wheel is used; this finishes the entire body of the shell, except the nose, which is turned in the lathe in one straight-in cut. The method shown at *C* is that

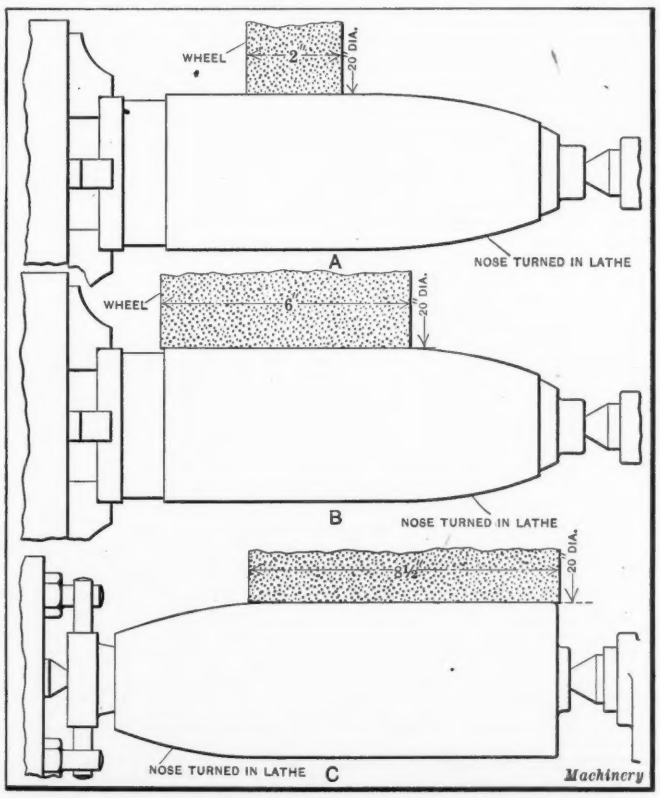


Fig. 119. Diagram illustrating Methods of finishing High-explosive Shell Bodies by turning and grinding

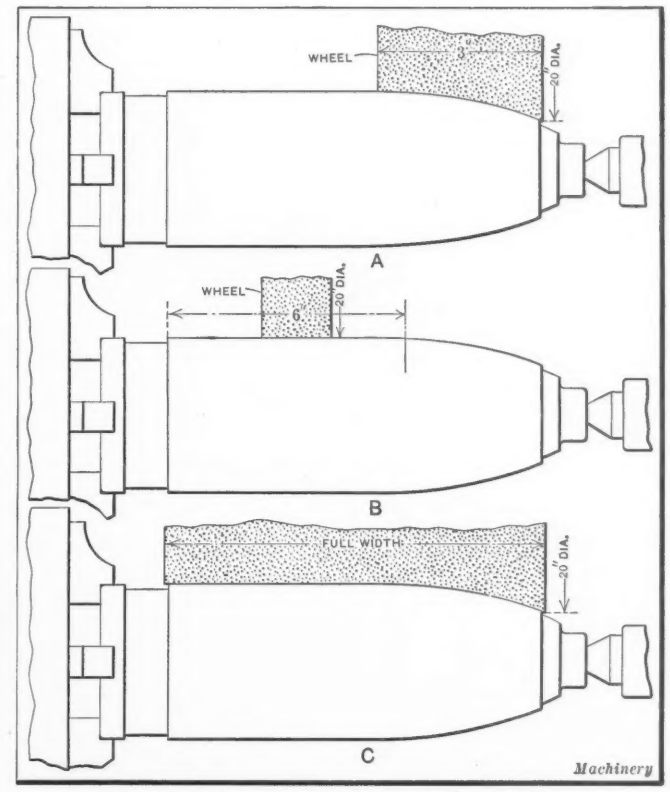


Fig. 120. Diagram illustrating Method of finishing High-explosive Shell by grinding

employed on the Ford-Smith grinder in British plants. The nose is turned in the lathe and the body is ground with a wide wheel, generally about 8½ inches. The grinding is done

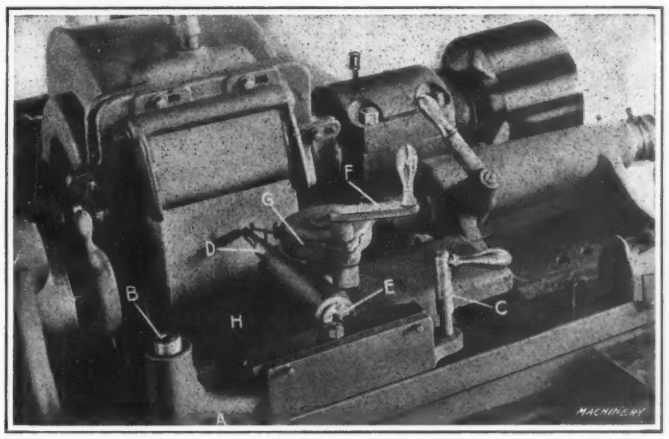


Fig. 121. Wheel-truing Device used on Ford-Smith Grinding Machine

completely across the shell, the band groove being cut in a subsequent operation. The production obtained on the 18-pound shell when these various methods are used differs considerably. When using the method shown at *A*, the production is about fifteen to twenty per hour; by method *B*, twenty to thirty per hour; and by method *C*, twenty-five to thirty per hour.

Fig. 120 shows methods of finishing high-explosive shell bodies by grinding all over. *A* and *B* show two methods of finishing high-explosive shells on a plain grinder. The procedure followed varies. In some cases the body is finished first and the nose later, whereas in others the nose, as shown at *A*, is ground first and then the body is ground as shown at *B*. The last method is that shown at *C* in Fig. 120. This is being used in Canada at the present time, and wheels as wide as 11½ inches face have been used, covering the entire length of the shell. On the 18-pound shell the production varies from twenty to twenty-five per hour, whereas on the 4.5 shell, using an 11½-inch face wheel, the production is somewhat less.

The special wheel-truing device used on the Ford-Smith plain grinder, shown in Fig. 118, is illustrated in Fig. 121. This

device is held on a swinging arm bracket *A*, fulcrumed on pin *B*, and located, when in position to true the face of the wheel, by stud *C*. The holder *D*, carrying the diamond tool, is provided at its rear end with a hardened cam surface that is kept in contact with the forming cam *E* by means of a spring located in the body of the attachment. The method of operating this device is as follows: After swinging the attachment into position and locking it, the wheel-slide is advanced until the diamond contacts with the wheel. Crank-handle *F* is then rotated. This carries a gear that meshes with another gear in the enclosed case *G*. The stud in this case extends down through the fixture and engages another gear operating in a rack. Consequently, the turning of this handle moves slide *H* back and forth, and traverses the diamond holder past the face of the wheel. This diamond truing device is only used occasionally to bring the wheel to the correct shape and to dress up new wheels. For slight dressing, as previously mentioned, a carborundum stick is used.

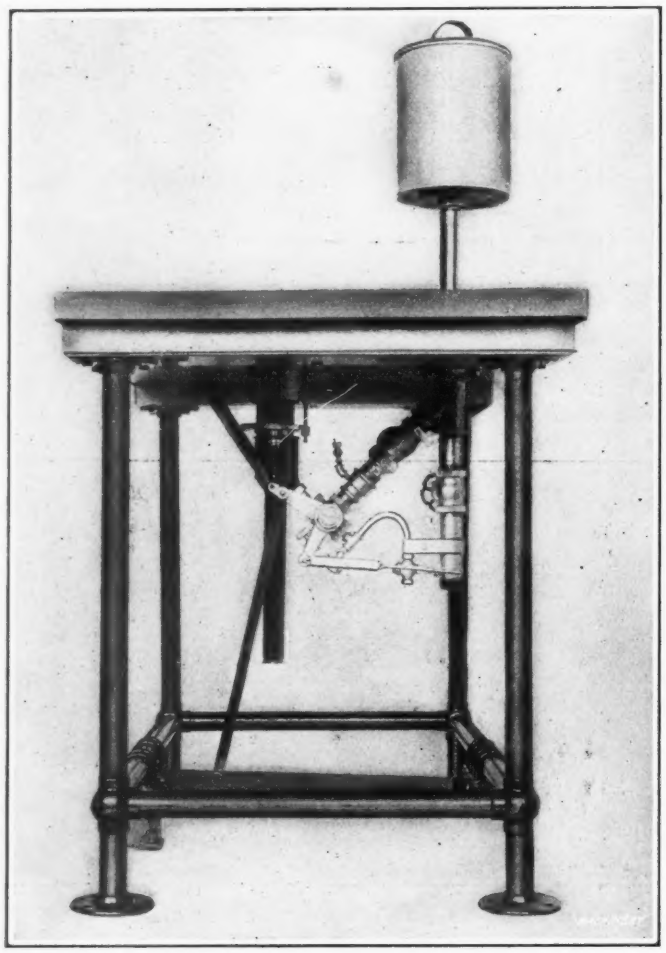


Fig. 122. Machine built by Spray Engineering Co. for spraying Interior of High-explosive Shells

VARNISHING INTERIOR OF HIGH-EXPLOSIVE SHELLS

A special machine for varnishing the interior of high-explosive shells is shown in Fig. 122. This machine, which is built by the Spray Engineering Co., Boston, Mass., is provided with an apparatus for spraying the necessary protective coating on the inside of the shell. The machine comprises a table with steel supporting frames, and with the operating mechanism placed beneath it. The usual coating material, such as varnish, asphaltum paint and similar compounds, is carried in a tank located above the operating table. The liquid passes down the hollow tank supports to an adjustable measuring device which controls the amount of material sprayed at each operation. A system of levers controls the motion of this device, cutting off the supply from the tank and admitting measured quantities of material to a channel leading to the spraying nozzle. The last part of this motion opens a connection to a compressed air supply which drives the coating material through the spray nozzles and distributes it evenly over the surfaces to be covered. A high working

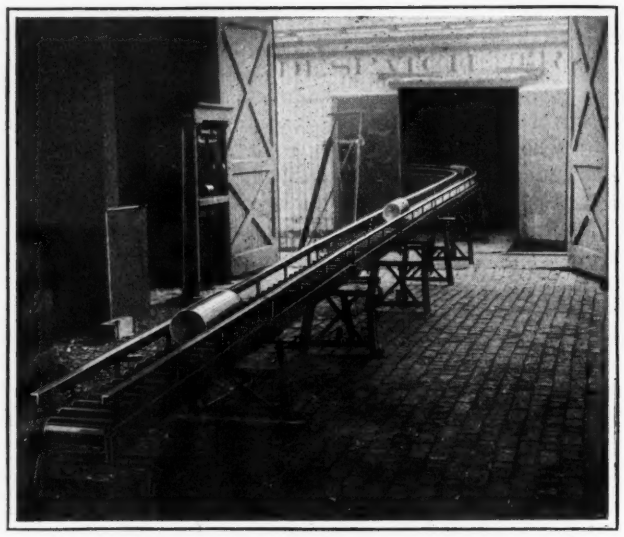


Fig. 123. Mathews Gravity Carrier transporting Shell Forgings

speed is thus obtained without waste of material and one setting of the measuring device insures delivery of a fixed quantity of the material to each shell.

To operate the machine the shell is inverted over the hole in the operating table. A slight pressure on the foot-lever connected with the operating lever moves the measuring device and admits compressed air. Upon the removal of pressure from the treadle, suitable coil springs return the mechanism to its original position, ready for the next operation. A particular feature of the machine is the device for admitting a fixed amount of coating material at each operation, which permits setting the mechanism to repeat any predetermined coating operation on a large number of similar parts. For readily changing over to different coating materials, drain valves and priming valves are provided, which permit a thorough cleaning of the measuring device and all pipe passages without taking the mechanism apart. The height of the spray head may be adjusted for coating shells of various dimensions, and auxiliary attachments including a movable spray head are used when it is required to cover a large surface or to meet other special conditions.

CONVEYING APPARATUS FOR THE RAPID HANDLING OF SHELLS

For conveying shell forgings from one department to another or from the shipping department to freight cars, etc., the Mathews Gravity Carrier Co. has designed conveying apparatus as shown in Figs. 123 and 124, respectively. Fig. 123 shows this gravity carrier being used for transporting forgings from a freight car to the machining department of a plant, whereas Fig. 124 shows a special arrangement of the carrier for handling shells that are boxed and ready for shipment. In this case the track part which extends into the shipping room is about two feet above the floor level and the

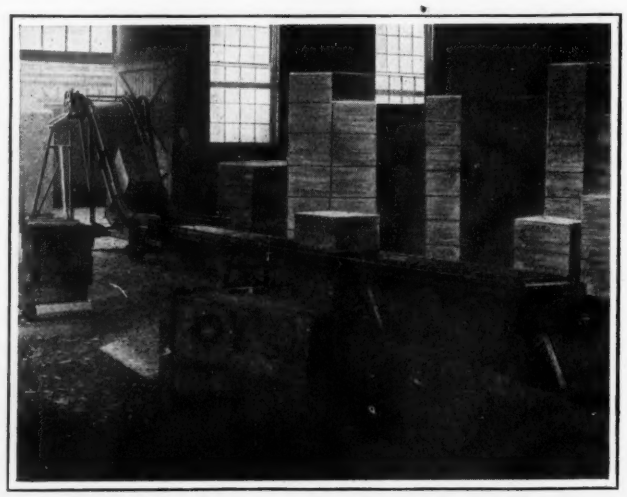
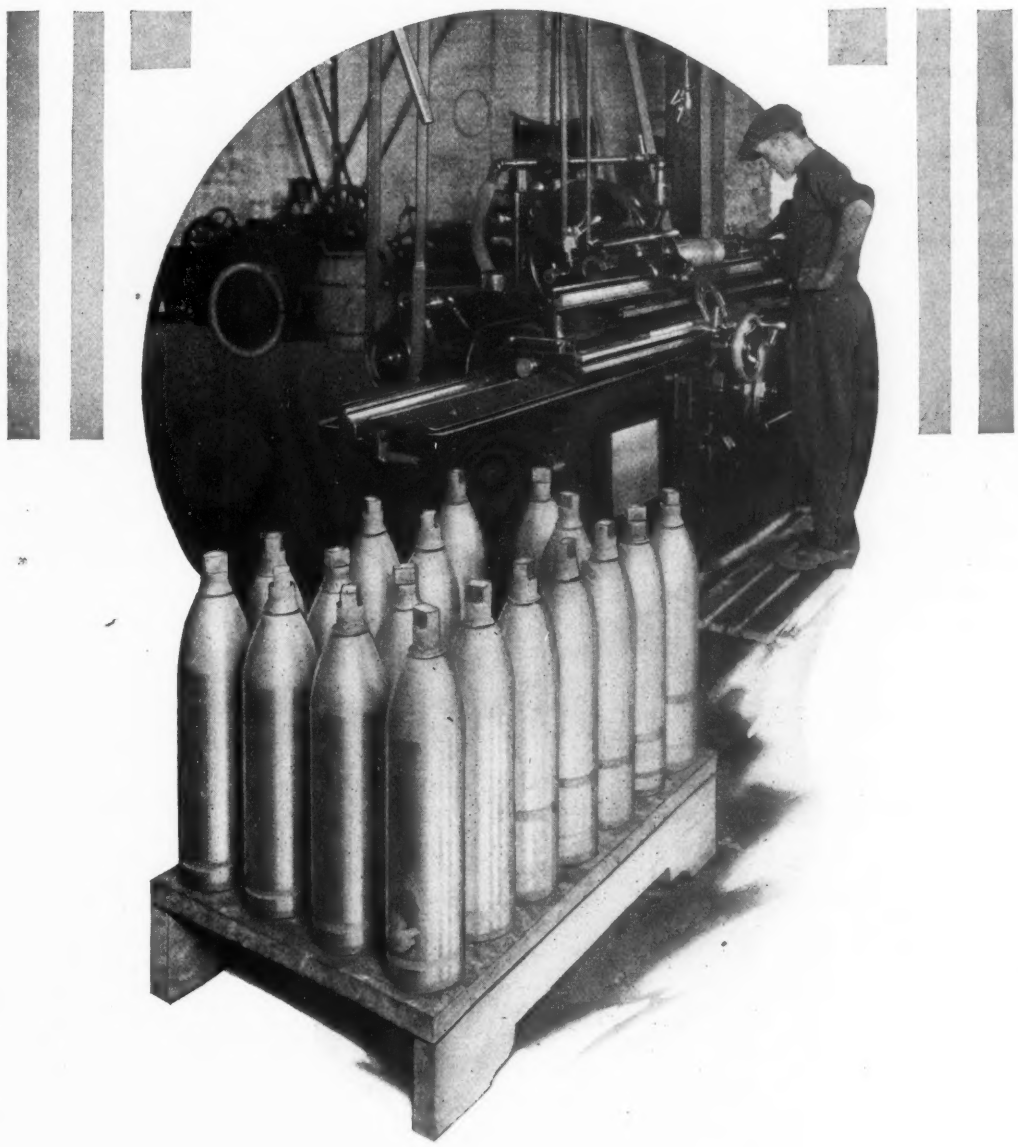


Fig. 124. Mathews Gravity Carrier with Elevator Unit loading Freight Car

inclined elevator arrangement lifts the boxes up so that they are located in the car four feet above the floor level. The idea of elevating the boxes is to have them within convenient reach of the shipper. The elevator is not necessary where the floor of the car is on the same level as the floor of the building.

The chief advantage of this conveying apparatus is that it is easily and quickly installed and is built up of separate units so that it can be added to without any extra cost except the cost for extra length of carriers and stands. The rollers are made from seamless cold-drawn steel tubing and run in ball bearings. The grade of the apparatus is from 2 to 3 per cent. Where it is necessary to lift the shells or other parts being transported from a floor into a car, a portable elevator is used as shown in Fig. 124. This elevator is driven by a one-horsepower motor and can be connected to a lamp socket. Another application of this system is where the carrier arrangement comes to the end of the building and it is necessary to return the work; to accomplish this, a double-deck arrangement is provided, the lower deck inclining one way and the upper deck the other way. Thus when the shells or work come to the end of the line, they are simply placed on the upper deck and are returned to the next series of machining operations, without any handling whatsoever. Another advantage of this system is that the shells or work do not need to touch the floor at all, and consequently expensive cement floors are not broken up by having heavy work dropped on them. Lifting the work off the carrier is also more convenient than lifting it from the floor.

The important feature of the Mathews gravity roller carriers is that natural gravity takes the place of other power conveyors, except where additional elevations are necessary or where shells, forgings and boxes must be elevated to upper floors. For this work the Mathews Gravity Carrier Co. makes automatic-incline or straight-lift elevators, which require only a very small motor.



DETONATING FUSES FOR HIGH-EXPLOSIVE SHELLS

THE British high-explosive shell described in connection with Fig. 3 carries a nose fuse of the concussion type, also shown in Fig. 9, which is made chiefly from brass parts with the exception of the adapter *B*, Fig. 125, and the gaine. These are made from soft steel. The body of the fuse, shown completely machined at *D* in Fig. 126 and at *C* and *D* in Fig. 127, is first cast in a sand mold in the form of a slug, as shown at *A* in Fig. 126. The composition from which this slug is made is about 59.18 per cent copper, 39.45 per cent zinc, 0.88 per cent manganese copper and 0.49 per cent phosphor copper. This composition is not arbitrary, but has been found to give the tensile strength required by the specifications.

The first operation consists in snagging and brushing the castings with a wire brush, but experiments are being made to force the casting through a simple shaving die that shaves off the straight surface and removes all objectionable projections. After casting, the slugs are sand-blasted or otherwise cleaned; they are taken to the Stewart furnace shown in Fig. 128 where they are heated to 1600 degrees F. The ovens of these Stewart gas furnaces are double ended, and a Zeh & Hahnemann percussion press, Fig. 130, is located at one end of the furnace. Three men are required for each forging press; one loads the furnace from the rear, the second man takes the heated forgings out of the front end of the furnace, puts them in the die and trips the press, whereas the third man removes them from the dies. After the slugs have reached a temperature of 1600 degrees F., they are removed from the furnace and placed in the dies shown in Fig. 129 and in Fig. 131 removed from the press. The furnace shown in Fig. 128 holds forty-eight slugs, and 1400 to 1500 forgings are secured from each press in a day of 9¾ hours. The ideal forging obtained from the dies is one in which there is 3/64 inch of material to remove all around. The dies shown in Figs. 129 and 131 are kept flushed with a compound consisting of 64 per cent oil, 32 per cent water, 3 per cent powdered graphite, and 1 per cent soda ash. The order in which these operations are accomplished, as well as the machines used, spindle speeds, and the production obtained, are given in Table V.

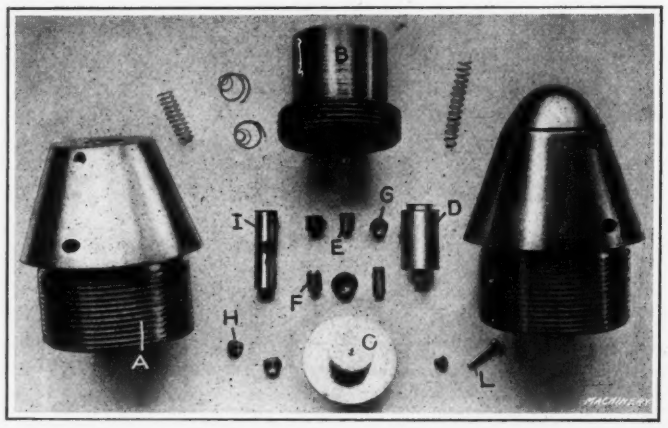


Fig. 125. British No. 100 Graze High-explosive Fuse dismantled and assembled

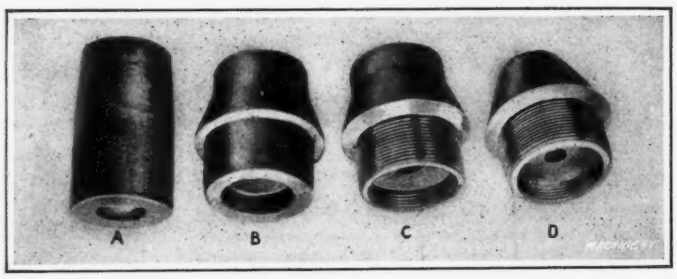


Fig. 126. Sequence of Operations on Body of British No. 100 Graze High-explosive Fuse

First Machining Operation on the Fuse Body

For the first machining operation, the brass body is held in an air chuck, as shown in Fig. 132, with the end subsequently to be threaded projecting. The first operation consists in turning the body and roughing the angle with the tool *G* in the front of the cross-slide. The second is facing end, also chamfering and roughing chamber with tool *A;* third, finish-counterboring and chamfering outside with tool *B;* fourth, under-cutting with tool *C;* fifth, taking cut across face with tool on rear of cross-slide; sixth, tapping

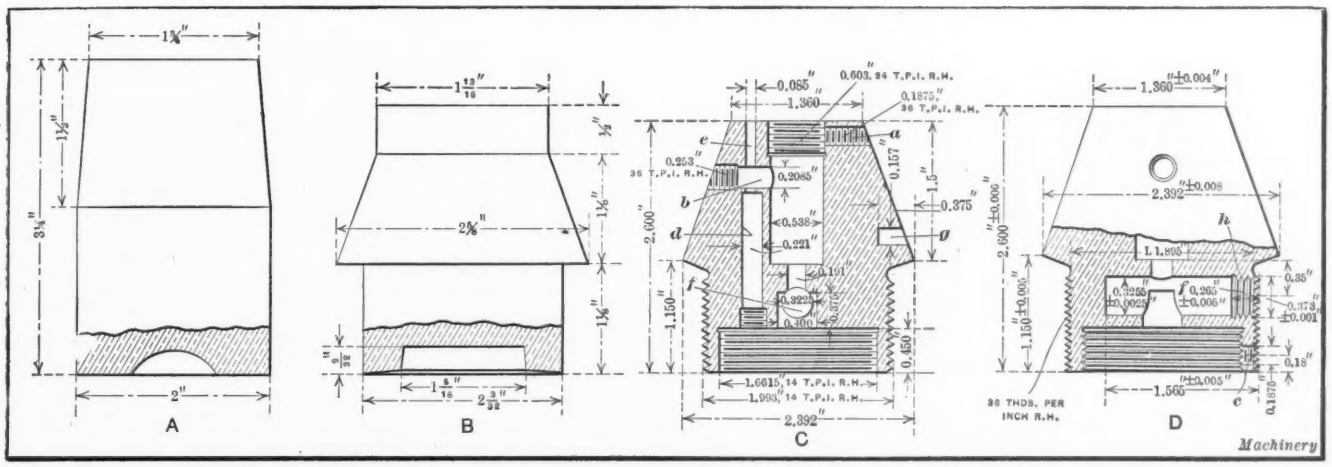


Fig. 127. Various Stages in the Manufacture of the British No. 100 Graze High-explosive Fuse

with tool *D;* seventh, threading with Geometric collapsing die *E;* eighth, drilling and reaming center hole with tool *F*. After threading in the machine, a hand threading operation is necessary to size the thread on the body. The lubricant used on this job is a mixed compound consisting of 1.06 per cent soda ash, 15.67 per cent mineral lard oil, and 83.27 per cent water.

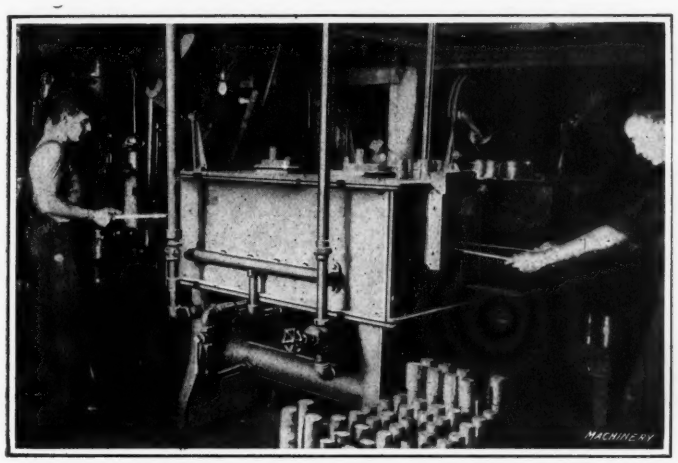


Fig. 128. Stewart Gas Furnace used for heating Castings previous to hot-pressing

Second Machining Operation on Fuse Body

The second machining operation on the fuse body consists in finishing the taper end. The threaded end, as shown in Fig. 133, is gripped in an air chuck and the following operations performed: First, face with cross-slide tool *G;* second, center with tool *A;* third, drill and rough-turn with tool *B;* fourth, rough-counterbore with tool *C;* fifth, recess with tool *D;* sixth, drill with tool *E;* seventh, tap with tool *F;* eighth, shave angle on body with shaving tool *H* held on rear of cross-slide. These operations practically finish the body with the exception of several drilling operations that are done on Leland & Gifford high-speed drilling machines by the aid of simple jigs.

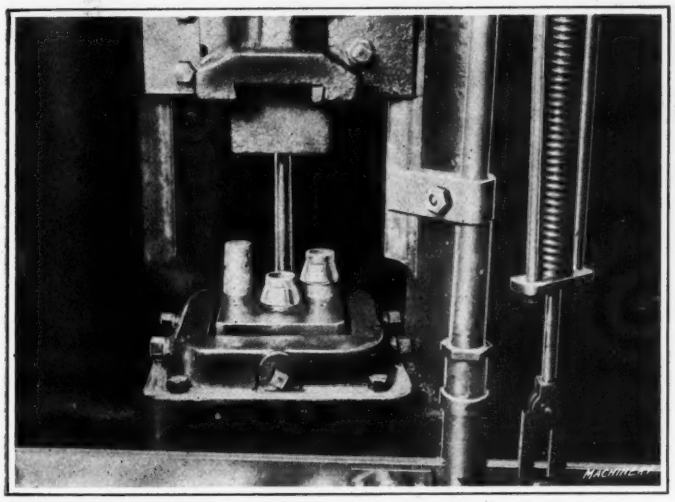


Fig. 129 Close View of Percussion Press shown in Fig. 130 showing Dies used and Casting before and after forging

Drilling Operations on the Fuse Body

Following the machining operations just described, the fuse body passes through a number of drilling, counterboring and tapping operations. These operations are all performed on Leland-Gifford drilling machines, as stated. By referring to Fig. 127, the sequence of operations may be followed.

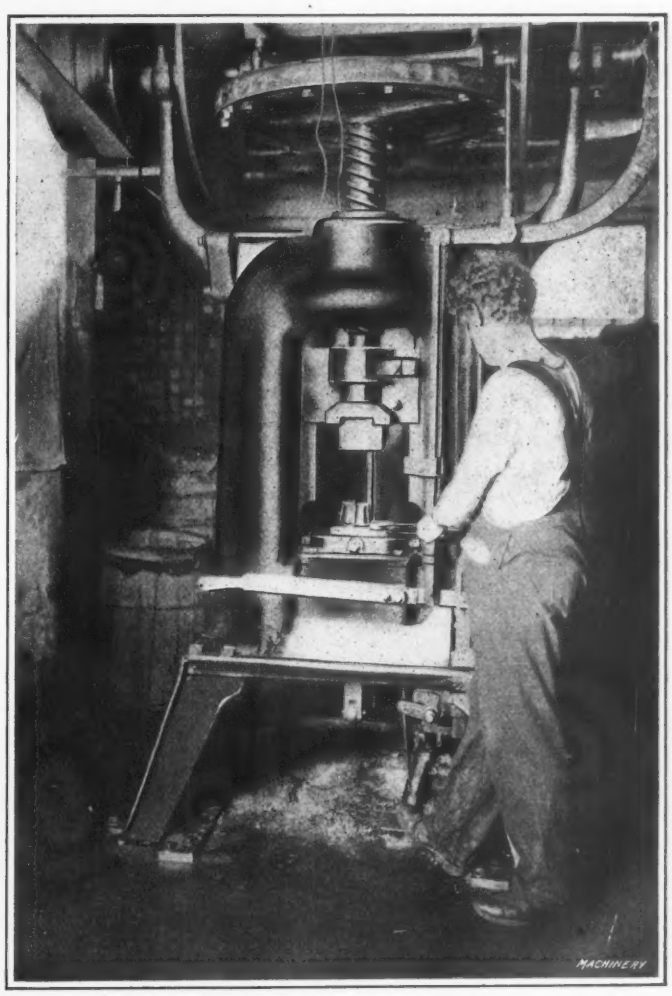


Fig. 130. Zeh & Hahnemann Percussion Press used in hot-pressing Fuse Bodies

The first drilling operation on the machined body consists in drilling the cap set-screw hole *a*, drilling and counterboring the centrifugal bolt hole *b*, and drilling the adapter set-screw hole *c*. For this operation, a three-spindle drilling machine is employed. The four operations are performed on the three-spindle machine because the cap set-screw hole *a* and the adapter set-screw hole *c* are the same diameter, and therefore machined by the same drill.

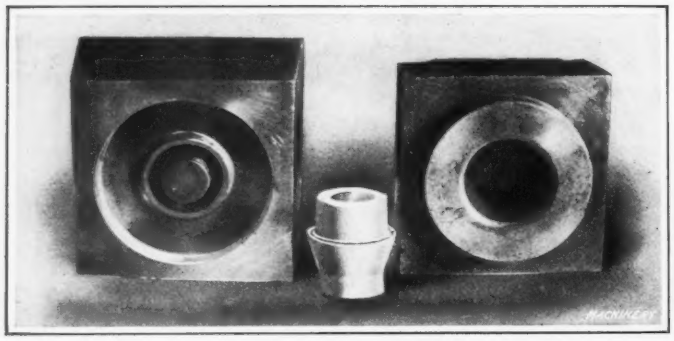


Fig. 131. Upper and Lower Dies used in Press shown in Fig. 130

The second set of drilling operations on the body consists in drilling the detent spring hole *d* with a drill in one spindle of a three-spindle drilling machine. The second spindle carries a counterboring tool that squares the bottom of the hole, and the third spindle carries a counterboring tool.

The third set of drilling operations on the body is the drilling of the hole for the reception of the detent and this is performed on a two-spindle drill press, each spindle carrying the same size drill, except that one is much longer than the other. The longer of the two drills is used with a special fixture for drilling two-thirds of the detent hole *e* from the bottom side. The hole is completed by drilling from the top, using a second fixture and the short drill in the second spindle of the machine.

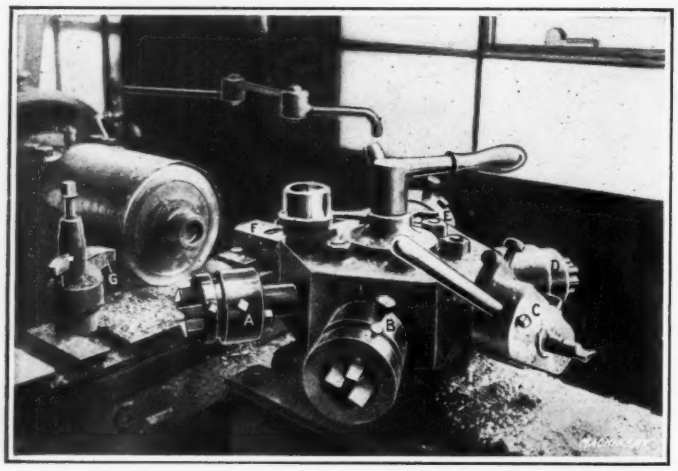


Fig. 132. Set-up on Warner & Swasey Brass-working Lathe for performing First Series of Machining Operations on Fuse Body

The fourth set of drilling operations on the fuse body is performed on a three-spindle drilling machine, and the first spindle carries a drill for drilling the central percussion pellet hole indicated at *f* in Fig. 127. The second spindle carries a counterboring tool, and the third spindle carries a bottoming tool.

The seventh operation on the fuse body is the milling of the oval wrench hole indicated at *g*. This is done in a single-spindle drilling machine, holding the work in a special fixture so that it may be moved backward and forward slightly to produce the oval hole required.

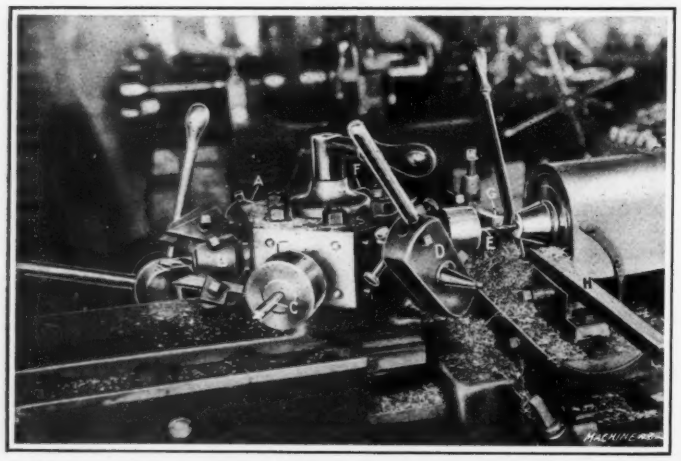


Fig. 133. Set-up on Warner & Swasey Brass-working Lathe for performing Second Series of Operations on Fuse Body

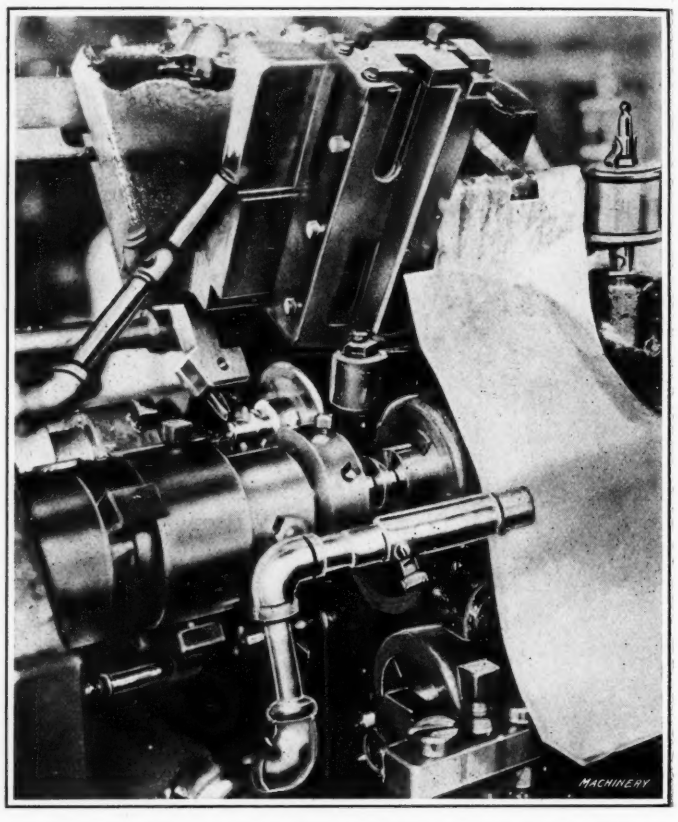


Fig. 134. Set-up on No. 55 Acme Multiple-spindle Automatic Screw Machine for machining Fuse Cap

The eighth operation on the fuse body is the recessing of the percussion pellet hole for the thread. This is indicated at *h* in Fig. 127. A single-spindle drilling machine is used equipped with a special fixture to provide for under-cutting.

The ninth set of operations on the fuse body consists in slightly countersinking or burring all of the holes. This is done with a large countersink in a single-spindle drilling machine, the fuse bodies being held by hand against the countersink.

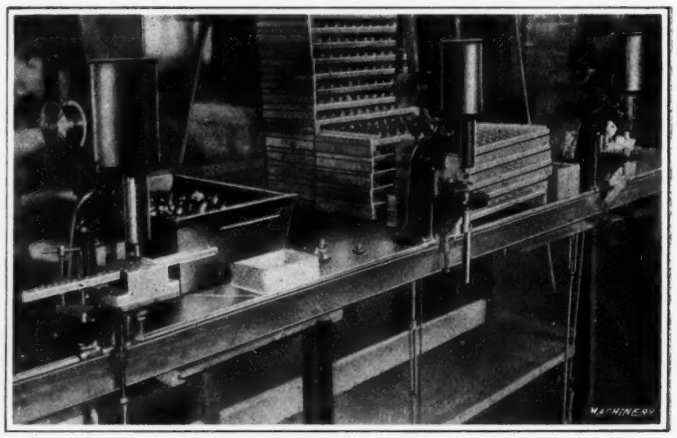


Fig. 135. Grant Riveting Machines used in riveting Needle in Percussion Needle Plug

The tenth and last set of operations on this part consists in tapping five holes, namely, the set-screw holes for the cap and adapter, the detent spring hole, the centrifugal bolt hole and the percussion pellet hole. Four separate machines are used for tapping, each of which carries a tapping head.

Machining the Fuse Cap

The fuse cap shown at *C* in Fig. 125 is made from brass rod 1⅜ inch diameter in an Acme No. 55 multiple-spindle screw machine, as shown in Fig. 134. The order of opera-

TABLE V. ORDER OF OPERATIONS ON BRITISH NUMBER 100 GRAZE FUSE

Name of Part	Character of Operation	Material	Machine	Speed, R. P. M.	Production Per Hour
Body	First Machining	Cast Brass	Hand Screw Machine	376	12 to 15
Body	Second Machining	Cast Brass	Hand Screw Machine	570	8
Body	Drill and Counterbore	Cast Brass	Leland-Gifford Three-spindle Drill	6000	65
Body	Drill and Counterbore	Cast Brass	Leland-Gifford Three-spindle Drill	6000	65
Body	Drill	Cast Brass	Leland-Gifford Two-spindle Drill	8000	120
Body	Drill and Counterbore	Cast Brass	Leland-Gifford Three-spindle Drill	4000	60
Body	Mill Wrench Hole	Cast Brass	Leland-Gifford Single-spindle Drill	6000	150
Body	Recess	Cast Brass	Leland-Gifford Single-spindle Drill	4000	375
Body	Countersink	Cast Brass	Leland-Gifford Single-spindle Drill	250	120
Body	Tap Five Holes	Cast Brass	Drilling Machine	150	..
Cap	Form and Cut Off	1 3/8" Brass Rod	No. 55 Acme Auto.	520	150
Cap	Drill	1 3/8" Brass Rod	Leland-Gifford Single-spindle Drill	8000	200
Adapter	Form, Drill, Shave, Counterbore, Thread, Cut Off	1 11/16" Soft Steel Rod	No. 56 Acme Auto.	290	45
Adapter	Counterbore, Drill and Tap	1 11/16" Soft Steel Rod	Model A Cleve. Auto.	....	60
Graze Pellet	Form, Neck and Drill	9/16" Brass Rod	No. 52 Acme Auto.	980	300
Graze Pellet	Drill	9/16" Brass Rod	Leland-Gifford Single-spindle Drill	8000	50
Graze Pellet	Drill, Bottom and Counterbore	9/16" Brass Rod	Leland-Gifford Three-spindle Drill	6000	150
Percussion Pellet	Turn, Chamfer, Drill, Recess, Tap, Cut Off	11/32" Brass Rod	No. 52 Acme Auto.	980	360
Percussion Pellet	Drill and Ream	11/32" Brass Rod	Leland-Gifford Three-spindle Drill	4000 to 8000	..
Percussion Det. Plug	Machine	13/32" Brass Rod	No. 515 Acme Auto.	1230	720
Percussion Det. Plug	Drill	13/32" Brass Rod	Leland-Gifford Single-spindle Drill	8000	200
Percussion Needle Plug	Machine	9/32" Brass Rod	No. 52 Acme Auto.	980	695
Percussion Needle Plug	Drill Four Holes	9/32" Brass Rod	Leland-Gifford Single-spindle Drill	8000	100
Bottom Detent	Form and Center, Drill, Form Hole, Cut Off	7/32" Brass Rod	No. 515 Acme Auto.	1230	720
Top Detent	Rough-finish-turn, Form, Chamfer, Shave, Cut Off	5/32" Phos. Bronze	No. 515 Acme Auto.	1230	210
Top and Bottom Detent	Assemble	5/32" Phos. Bronze	By Hand	....	..
Detent Plug	Machine	9/32" Brass Rod	No. 515 Acme Auto.	1230	720
Centrifugal Bolt	Shave and Cut Off	7/32" Brass Rod	No. 515 Acme Auto.	1230	1020
Detent Spring Screw	.....	Brass Rod	No. 515 Acme Auto.	1230	700
Cap Screw	.....	3/16" Steel Rod	No. 515 Acme Auto.	1230	500
Cap Screw	Mill Slot	3/16" Steel Rod	Acme Screw Slotter	....	2500
Adapter Screw	.....	3/16" Steel Rod	No. 515 Acme Auto.	1230	600
Adapter Screw	Mill Slot	3/16" Steel Rod	Acme Screw Slotter	....	1500
Detent Plug Screw	.....	9/32" Brass Rod	No. 52 Acme Auto.	980	750
Detent Plug Screw	Mill Slot	9/32" Brass Rod	Acme Screw Slotter	....	1800

Machinery

tions is: first, form and center; second, drill, square and neck; third, thread with button die; and fourth, cut off. The production on this particular piece is given in Table V; after coming from the screw machine it is put through a

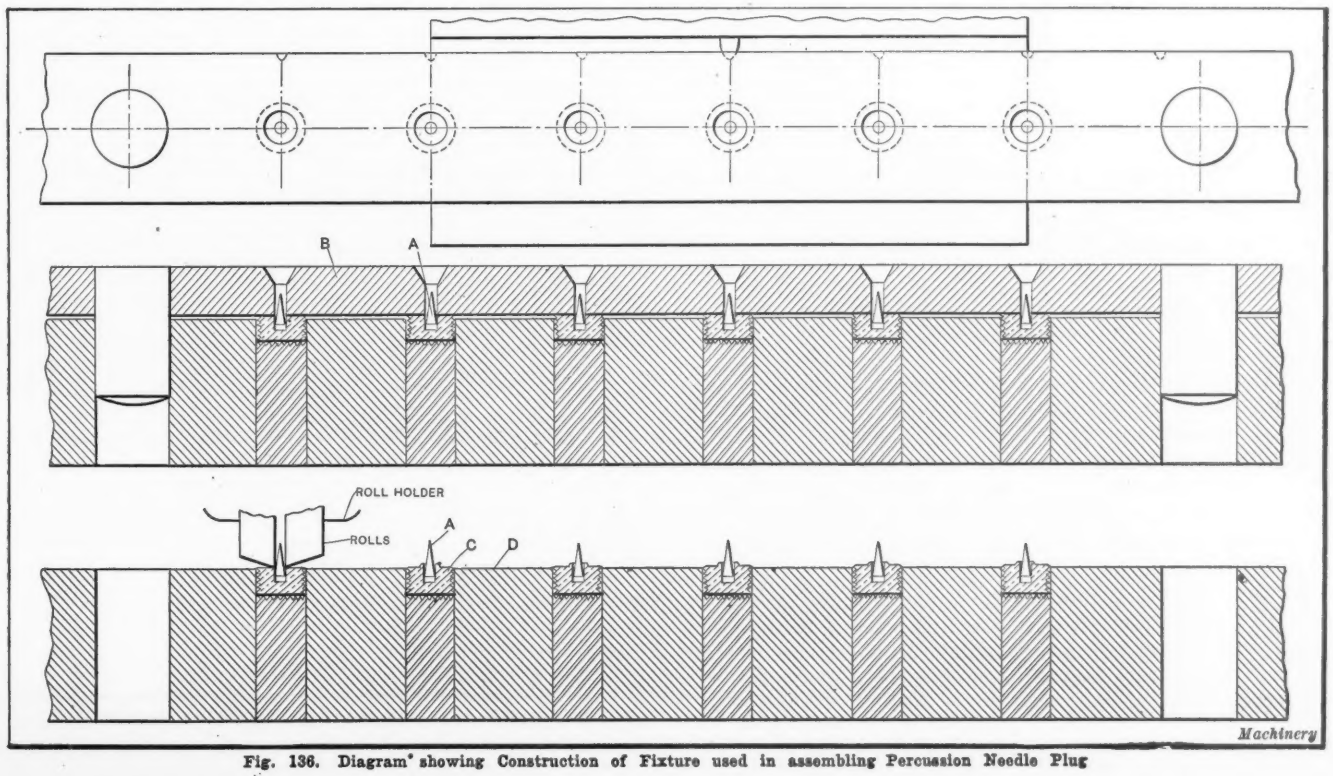


Fig. 136. Diagram showing Construction of Fixture used in assembling Percussion Needle Plug

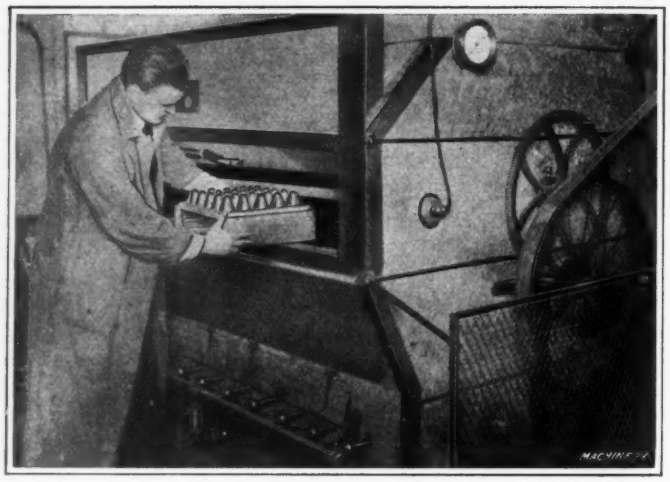


Fig. 137. Baking Varnish on High-explosive Shell Fuses

chip separator where the oil and chips are separated. The next operation is drilling the two wrench holes, which is handled on a single-spindle drilling machine, the jig being shifted on the table to drill the two holes.

Operations on the Graze Pellet

The graze pellet shown at *D* in Fig. 125 is made from 9/16-inch brass rod in a No. 52 National-Acme multiple-spindle automatic screw machine. The operations are as follows: first, turn full diameter and also 0.370 diameter with a double tool, also drill and start neck; second, recess and continue neck; third, tap and finish neck; fourth, cut off. The piece is finished upon leaving the screw machine. The production is given in Table V, which also includes a complete summary of the operations performed on the various parts of this fuse.

There are two drilling operations on the graze pellet. The first consists in drilling the small fire hole through the entire length of the piece. This is done in a single-spindle drilling machine and is followed by the operations on the upper end of the piece, where the detonating cap is held. The operations on this end are performed in a three-spindle drilling machine; the first spindle carries the drill for producing the large hole, the second carries a counterboring tool and the third a facing tool for the bottom of the hole.

Operations on Centrifugal Bolt and Plugs

The centrifugal bolt *E*, Fig. 125, is made from brass rod and the operations are very simple, consisting merely in shaving and cutting off. The percussion detent plug *G* and the percussion needle plug *H* are also simple screw machine jobs. The needles are made of steel and are swaged down to a fine point and then hardened. The spinning in place of the needle point is done on the Grant rivet spinning machines shown in Fig. 135, on which a simple fixture shown by the diagram Fig. 136 is employed. Two girls are employed on this work; one inserts the needles *A* in plate *B*, and the plugs *C* in plate *D*, and the other operates the machine. The holes in the top plate are large enough to allow the needles to drop through freely and enter the plugs. Then the top plate is removed and the fixture placed on the table of the spinning machine. The spinning rolls are brought down in contact with the plugs consecutively and spin in the edge, holding the needles firmly in place. The plugs are prevented from rotating by steel inserts which are knurled on their top faces. Location of the various holes under the spinning machine is accomplished as shown in the plan view, Fig. 136.

The operations on the percussion detonator plug are performed on a single-spindle drilling machine, and consist in drilling the two small holes with the aid of a swivel jig.

The four small fire holes in the percussion needle plug are drilled after the needle has been swaged in place. The drilling operation is left until last, as otherwise the swaging operation would close up the fire holes.

Machining Operations on Percussion Pellet

The percussion pellet shown at *I* in Fig. 125 is made from 11/32-inch diameter brass rods in a multiple-spindle automatic screw machine. The first operation consists in turning with a box-tool, chamfering and squaring the threaded end, also drilling the hole and squaring the bottom; second, recessing; third, tapping; and fourth, drilling small hole and cutting off. The hole in the opposite end of the percussion pellet and the one in the side are drilled in a three-spindle drilling machine. The same size drill is used for drilling the large cross hole and the end hole. This drill is held in the first spindle, and a smaller drill, held in the second spindle, drills the small cross hole, whereas the third spindle carries a taper reamer for tapering the large cross hole.

Operations on Top and Bottom Detents

The bottom and top detents shown at *F* and *L*, respectively, in Fig. 125 are made with a simple tool equipment. The top detent *L* is made from 5/32-inch bronze rod in a screw machine, whereas the bottom detent *F* is made from brass rod 7/32-inch diameter in a screw machine. The operations on the top detent are: first, rough-turn and form head; second, finish-turn and chamfer; third, shave from head to point; fourth, cut off. The operations on the bottom detent are: first, form and center; second, drill; third, form hole; and fourth, cut off.

Operations on Ada ter

The adapter shown at *B* in Fig. 125 is produced in three operations, the first being performed on an Acme No. 55 multiple-spindle automatic screw machine. The first series of operations is as follows: first, rough-form and drill; second, shave and counterbore; third, thread outside diameter; and fourth, cut off. The second series of operations, performed on a Cleveland automatic screw machine provided with a magazine attachment, is: counterbore, tap and drill. The third operation is performed in a Leland-Gifford drilling machine and consists in drilling the two small holes. The other small parts, such as screws, etc., are regular screw machine jobs and are simple to manufacture.

Assembling

The assembling is done in the following order: First, the percussion pellet, spring and detonator plug are inserted in the cross hole; second, the graze pellet is dropped into place; third, the centrifugal bolt and screw are inserted from the side; fourth, combined detent, spring and screw plug are inserted from the base; fifth, the creeper spring is put in from the top and the cap screwed in place. The set-screw for the cap and the adapter are then inserted and finally the gaine is screwed in and the job is finished. The lacquering of the completed fuse is done by spraying as shown in the initial illustration on page 314 and lacquered fuses are

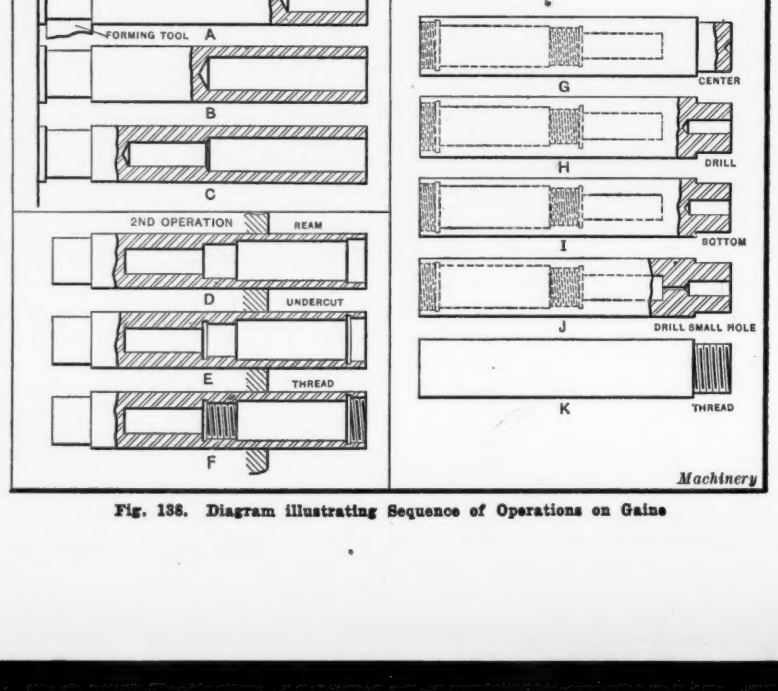


Fig. 138. Diagram illustrating Sequence of Operations on Gaine

then put in the rotating oven shown in Fig. 137 and baked until the varnish is dry. This oven has six shelves that work on the principle of a Ferris wheel.

MACHINING BRITISH HIGH-EXPLOSIVE FUSE GAINE PARTS

The gaine which forms the exploder member of the British No. 100 graze fuse shown in Fig. 9 is shown assembled and in detail in Fig. 139. As will be seen from this illustration, the gaine comprises three parts, *viz.*, body *A*, center plug *B* and closing or bottom plug *C*. The body *A* of the gaine is made from cold-rolled steel, and in one plant the first operation is handled in a No. 53 Acme multiple-spindle automatic

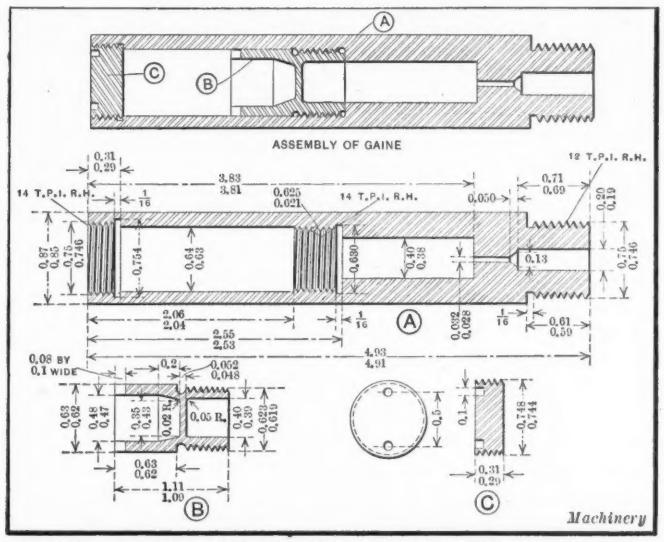


Fig. 139. Assembly and Details of Gaine used in British No. 100 Graze High-explosive Shell Fuse

in the order shown in Fig. 138. The order of machining operations performed at the first chucking is shown from *A* to *C* inclusive, and is as follows: First position, drill large hole one-third depth, using floating drill-holder, and form the thread diameter from cross-slide; second, drill large hole to shoulder; third, drill small hole; fourth, cut off.

In the drilling, a stepped lead cam is used so that the drills can be backed out to clean out the chips and assist the lubricant in getting to the cutting points of the drills. The outer surface of the gaine is not finished and the holes are not reamed. The cutting speed is 100 surface feet per minute, and the production is sixty per hour.

The second series of operations shown in Fig. 138 is performed on a No. 2 plain-head Warner & Swasey turret lathe, as follows: first, ream the four diameters of the hole with a stepped reamer; second, under-cut at the bottom of the two threaded sections (this is done with a tool having two cutting points properly spaced); third, tap the two holes with a double threaded tap. The production is thirty pieces per hour and the cutting speed, except for the tapping, is 100 surface feet per minute.

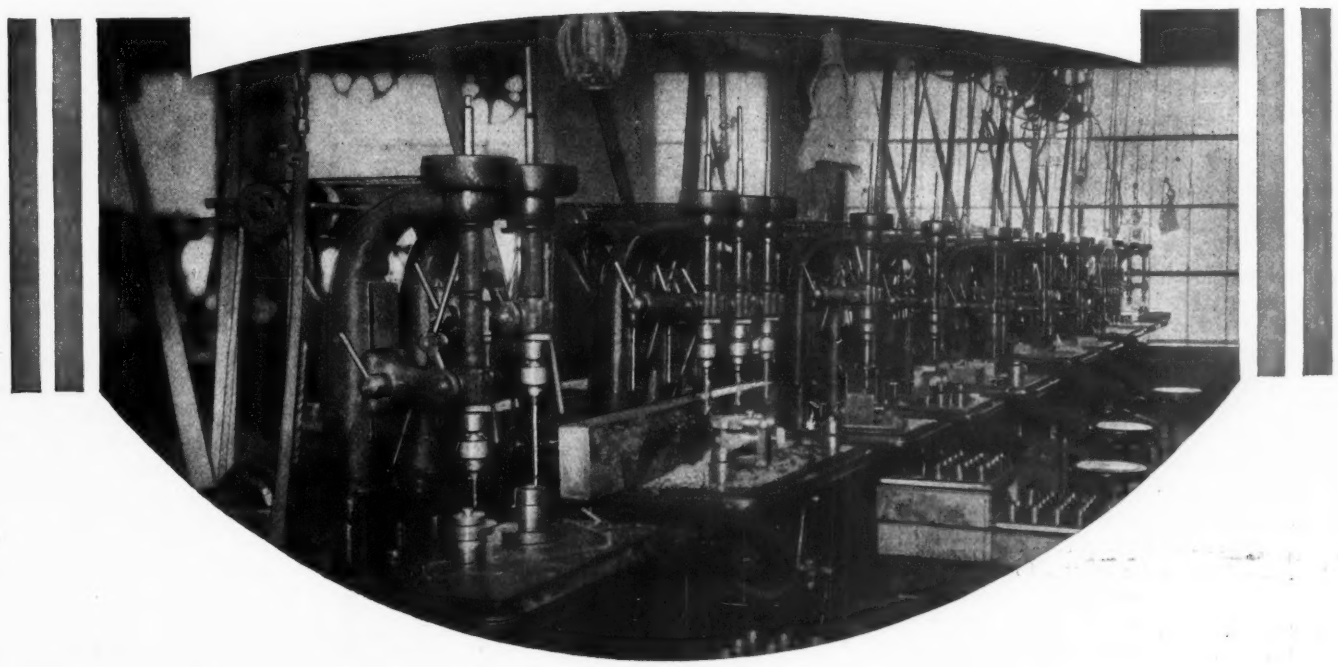
The third series of operations on the gaine body, shown to the right in Fig. 138, is performed on a No. 2 plain-head Warner & Swasey turret lathe, and the piece is held with the threaded end outward. The operations are: first, center; second, drill large hole; third, form bottom of hole; fourth, drill small hole with a high-speed drilling attachment; fifth, thread external diameter with a self-opening die. The cutting speeds on this operation are 100 surface feet per minute and the production is thirty pieces per hour. In the plant where this information was obtained, considerable trouble was experienced in drilling the small hole. Attempts were made to produce this hole in a high-speed drilling attachment, with poor results. The method shown at *J* is recommended as being more satisfactory, as in this case both work and drill revolve.

Machining the Center Plug

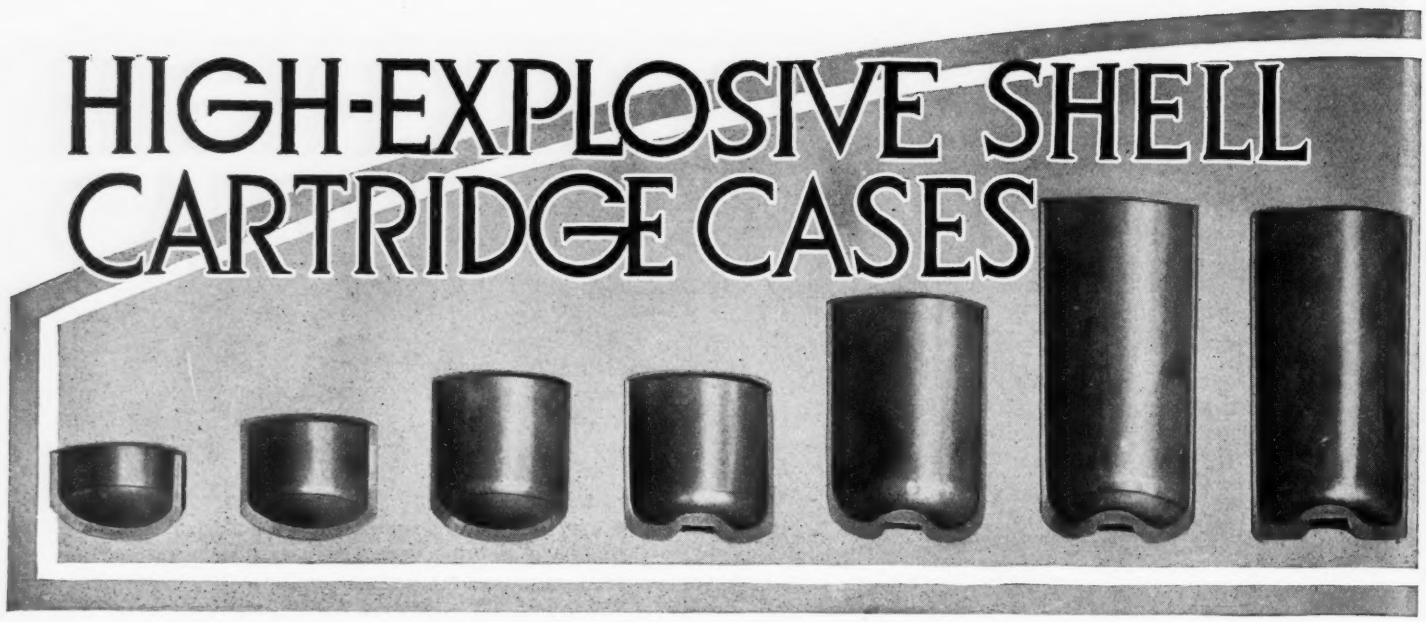
The center plug shown at *B* in Fig. 139 is made from hot-rolled machine steel and is completed in two operations. The first series of operations is performed on a No. 53 Acme multiple-spindle automatic. The operations are: first, form the entire length of the piece and drill small hole; second, shave outside diameter and square bottom of hole; third, thread; fourth, cut off.

The second series of operations is performed on a No. 2 plain-head Warner & Swasey turret lathe in the following order: first, center drill; second, drill; third, form hole with special counterboring tool; fourth, face end with tool on rear cross-slide. These pieces are handled at the rate of forty-five per hour. The work on this piece is completed by a simple slotting operation on an Acme screw slotter.

The machining of the bottom plug *C*, Fig. 139, is performed on a No. 53 Acme multiple-spindle automatic. This part is made of cold-rolled steel and turned at a speed of 100 surface feet per minute. The order of operations is: form external diameter; second, face end; third, thread; fourth, cut off. This piece is produced at the rate of 180 per hour. The drilling of the two holes in the end of this plug is performed in a drilling machine with the aid of a simple jig.



HIGH-EXPLOSIVE SHELL CARTRIDGE CASES



The cartridge case used in the British 18-pound quick-firing field gun is made from an alloy of copper and zinc, generally 70 per cent electrolytic copper and 30 per cent zinc. The exact composition of the alloy, however, is left to the discretion of the manufacturer, but the completed cartridge case must, of course, be of the required specifications for strength and elasticity. The number of redrawing and annealing operations on the cartridge case is never less than six, and in addition two tapering operations must be performed to bring the mouth of the shell to the correct diameter and the body to the right shape. The practice followed in plants making this cartridge case does not differ materially in regard to the number of drawing operations, but of course there is some difference in the methods used in handling the work. The following description covers the method used by a large concern that turns out 4000 18-pound cartridge cases per day of ten hours.

Blanking and Cupping

The first operation on the cartridge case is to cut out a blank 6.22 inches diameter from a sheet 0.380 inch thick. This operation is seldom handled by the firm making the cartridge cases, most firms preferring to buy the blanks from manufacturers that make a specialty of this business. The blank is usually cut out in a geared punch press, and the production is about 400 blanks per hour. Usually the blank is in the annealed condition when received by the cartridge case manufacturer. Assuming that the blank is purchased in the annealed condition, the next operation is cupping. In the plant where the following data was obtained, this operation is performed in a Toledo press as shown in Fig. 140. One operator can turn out 4000 cups in ten hours. On this operation, a production as high as 600 per hour can be obtained, but this pace cannot be kept up by one man. The shape and size of the cup after the cupping operation is shown at *B* in Fig. 143. Table VI gives the complete order of operations.

Fig. 140. First Operation—cupping in a Toledo Press

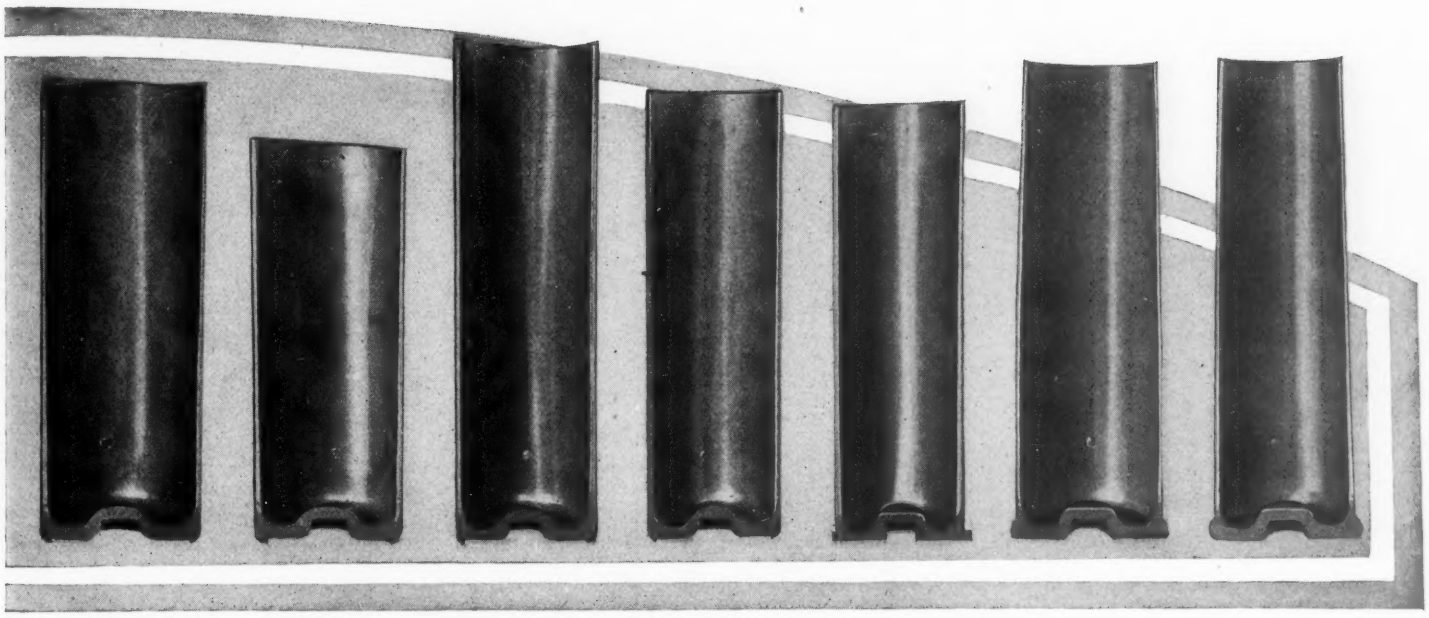
Annealing

Following the cupping operation, the metal is hardened somewhat and consequently annealing is necessary to restore the required ductility. The hardness of the metal is also tested by means of the scleroscope after each press and annealing operation, and in this plant one per cent of the daily production is given this test. This subject will be fully dealt with later. The annealing is done in a special furnace as shown in Fig. 141. These furnaces are about 6 feet wide by 24 feet long, and the cases are loaded into trays and fed into the furnace at the loading end by a ram operated by compressed air. The trays used for this purpose hold, on an average, fifty-six cups, the number increasing as the diameter of the case is reduced, and each furnace holds eight trays. The furnaces are kept at a constant temperature of 1250 degrees F., and the cups are annealed for one hour and four minutes at this temperature. This is the average length of time that each tray is allowed to remain in the furnace. The loading and unloading is carried on every eight minutes. After annealing, the cups are removed from the furnace and immediately immersed in water. There are six pyrometers in each furnace for controlling the temperature, three on each side. These pyrometers are tested every fifteen minutes, as shown in Fig. 145, so that any variation in the temperature of the furnaces can be immediately checked up. After cooling in water, the cups are taken to the pickling bath, where they are immersed in a solution of twenty parts water to one part sulphuric acid. They are then removed from this pickling solution and immersed in a high caustic soda bath, after which they are washed in warm water to remove all traces of the acid.

It should be mentioned here that all firms engaged in this work do not follow this procedure in cooling and washing. One concern, in particular, believes that the rapid cooling of the cases in water affects their physical properties, and hence allows the cases to cool off in the air after each annealing operation. When cool, the cases are immersed first in a bath containing a weak solution of sulphuric acid and then in a weak bath of cyanide of potassium, after which they are rinsed in water.

First and Second Redrawing and Indenting Operations

Following the cleaning of the cups, they are taken to another Toledo press shown in Fig. 146, where the first redrawing operation is accomplished. For this, one machine and two men are required. The production is 400 per hour. It will be noticed in Fig. 143 at *C* that the thickness of the bottom of the case remains the same, the sides alone being reduced in thickness and in-



creased in length. It is important that this thickness at the base be retained. After this, the cases are annealed, washed, etc., as previously described. The only difference here is that the pan holds sixty-three instead of fifty-six cases, this being due to the smaller diameter of the cases.

The second redrawing operation, *D*, Fig. 143, is accomplished in the same manner as the first, and the production is also the same, 400 per hour, two operators being required. Following the second redrawing operation, the cups are not annealed but are taken directly to the first indenting operation, the result of which is shown at *E* in Fig. 143. This operation is accomplished in the Toledo press shown in Fig. 147. Here it will be noticed that for indenting the case is placed on the lower punch *A*. Upon the descent of punch *B*, the lower punch is forced down into the die, exposing the indenting punch that is located inside of it. The case also goes down into the die and consequently is prevented from being distorted. Upon the up stroke, the case is ejected from the die by the double action of the press, and to provide against any chances of its sticking on the punch *B*, an ejector *C* is provided. In this operation only one operator is required and the production is 300 per hour. The important point to observe in this case is the depth of the indent. This, as shown at *E* in Fig. 143, must be 7/16 inch. Following indenting, the cases are again annealed as previously described, the pans accommodating sixty-eight cases each.

Third and Fourth Redrawing and Second Indenting Operations

The third redrawing operation is accomplished in a No. 57 Toledo press, as shown in Fig. 148. The production on this operation is 200 cases per hour, and the case is drawn out to the length shown at *F* in Fig. 143, and also reduced slightly in diameter. Two operators are required for this operation. After redrawing, it is taken to the annealing furnace and annealed, washed, etc., as previously described. The annealing pans accommodate seventy-two cases each.

The fourth redrawing operation is accomplished in a No. 857 Toledo press; the production is somewhat less, being 150 cases per hour, and two operators are required. The result of this operation is shown at *G* in Fig. 143. Following the fourth redrawing operation, the cartridge case is given the second indent as shown in Fig. 150. Reference to *H* in Fig. 144 will show that the head of the case is somewhat flattened in this operation, leaving a projection raised around the outer rim. The depth from the flat surface of the head to the bottom of the indent is the most important dimension; this depth on the 18-pound cartridge case must be 17/32 inch. The production at this operation, two operators being employed, is 250 cases per hour. Following the second indent, the cases are again annealed as previously described, washed, etc. The pans, in this case, carry seventy-eight cases, a greater number being accommodated because of the reduced diameter.

The presses used in performing the cupping, redrawing, reducing and heading operations vary in ram capacity from 500 to 1200 tons pressure per square inch.

Fifth and Sixth Redrawing and Second Trimming Operations

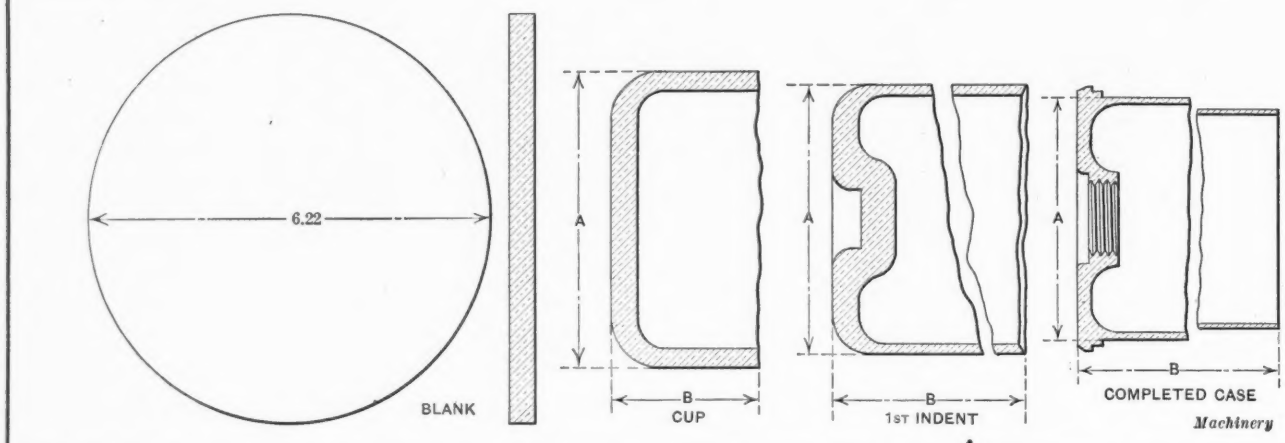
Following the second indent, the fifth redrawing operation is performed. This is accomplished in a No. 857 Toledo press, and the production is 150 per hour. The condition of the case after this operation is shown at *I* in Fig. 144. Before annealing, the mouth end of the case is trimmed. This operation is necessary because the case becomes quite ragged on the mouth end and would tear in the sixth redrawing operation if the excess stock were not removed from the open end. The total length of the case after the fifth redrawing operation averages 10⅝ inches and it is trimmed to 10½ inches. In many cases, as the punch wears small it is not necessary to perform this trimming operation because the wall is thicker.

The trimming of the mouth of the case is accomplished in the Toledo trimming machine shown in Figs. 149 and 151. A close view showing the shape of the simple disk cutter may be seen in Fig. 149. Two operators are necessary for this trimming operation; one holds the case on the arbor and the other does the trimming. The production is 350 per hour. Some changes have been made in this machine. The regular cutter-head has been removed and a cross-slide substituted. This cross-slide is operated by a lever, as shown, and carries a toolpost to which a circular friction disk cutter *A* is held, as shown in Fig. 149.

After trimming, the cases are again annealed, as previously described, each pan holding eighty-eight cases. The sixth

Fig. 141. Annealing Cartridge Cases

TABLE VI. ORDER OF OPERATIONS ON BRITISH 18-POUND CARTRIDGE CASE



Number of Operation	Character of Operation	A, Inches	B, Inches	Machine Used	Lubricant	Furnace Used	Temperature of Furnace Degrees F.	Bath	Production Per Hour
1	Blanking	6.220	0.380	Toledo No. 57 Press	.....	.....	.....	.....	400
2	Cupping	$4\frac{1}{2}$	$2\frac{5}{8}$	Toledo No. 59 Press	"New Era"	.....	.....	.....	400
3	Anneal for 1 Hour 4 Minutes	...	...	.....	.....	Special	1250	Water Cooled*	420
4	First Redrawing	$4\frac{7}{32}$	$3\frac{17}{32}$	Toledo No. 59 Press	"New Era"	.....	.....	.....	400
5	Anneal for 1 Hour 4 Minutes	...	...	.....	.....	Special	1250	Water Cooled*	472
6	Second Redrawing	$4\frac{3}{32}$	$4\frac{15}{16}$	Toledo No. 58 Press	"New Era"	.....	.....	.....	400
7	First Indenting	$4\frac{3}{32}$	$4\frac{15}{16}$	Toledo No. 59¼ Press	.....	.....	.....	.....	300
8	Anneal for 1 Hour 4 Minutes	...	...	.....	.....	Special	1250	Water Cooled*	510
9	Third Redrawing	$3\frac{31}{32}$	$5\frac{3}{4}$	Toledo No. 57 Press	"New Era"	.....	.....	.....	200
10	Anneal for 1 Hour 4 Minutes	...	...	.....	.....	Special	1250	Water Cooled*	540
11	Fourth Redraw	$3\frac{27}{32}$	$8\frac{1}{4}$	Toledo No. 857 Press	"New Era"	.....	.....	.....	150
12	Second Indenting	$3\frac{27}{32}$	$8\frac{1}{4}$	Toledo No. 59¼S Press	.....	.....	.....	.....	250
13	Anneal for 1 Hour 4 Minutes	...	...	.....	.....	Special	1250	Water Cooled*	585
14	Fifth Redrawing	$3\frac{25}{32}$	$10\frac{5}{8}$	Toledo No. 857 Press	"New Era"	.....	.....	.....	150
15	First Trimming	$3\frac{25}{32}$	$10\frac{1}{2}$	Toledo Trimmer	.....	.....	.....	.....	350
16	Anneal for 1 Hour 4 Minutes	...	...	.....	.....	Special	1250	Water Cooled*	660
17	Sixth Redrawing	$3\frac{25}{64}$	$14\frac{1}{4}$	Toledo No. 856 Press	"New Era"	.....	.....	.....	120
18	Second Trimming	$3\frac{25}{64}$	$11\frac{1}{16}$	Toledo Trimmer	.....	.....	.....	.....	350
19	Heading	$3\frac{25}{64}$	$11\frac{1}{2}$	Toledo No. 666 Press	.....	.....	.....	.....	150
20	Mouth Anneal 1 Minute	...	...	.....	.....	Special	800	Cool in Air	720
21	First Tapering	$3\frac{3}{8}$	$11\frac{1}{2}$	Toledo No. 114 Press	"New Era"	.....	.....	.....	250
22	Second Tapering	3.34	$11\frac{5}{8}$	Toledo No. 114 Press	"New Era"	.....	.....	.....	250
23	Machine Head and Mouth	4.065 head	11.58	Bullard, Trimming, Chamfering and Facing Machine	.....	.....	.....	.....	35
24	Inspect (ten operations)	...	...	Standard and Special Gages	.....	.....	.....	.....	400

Machinery

* After cooling in water, cases are dipped in weak sulphuric acid solution and rinsed in warm water.

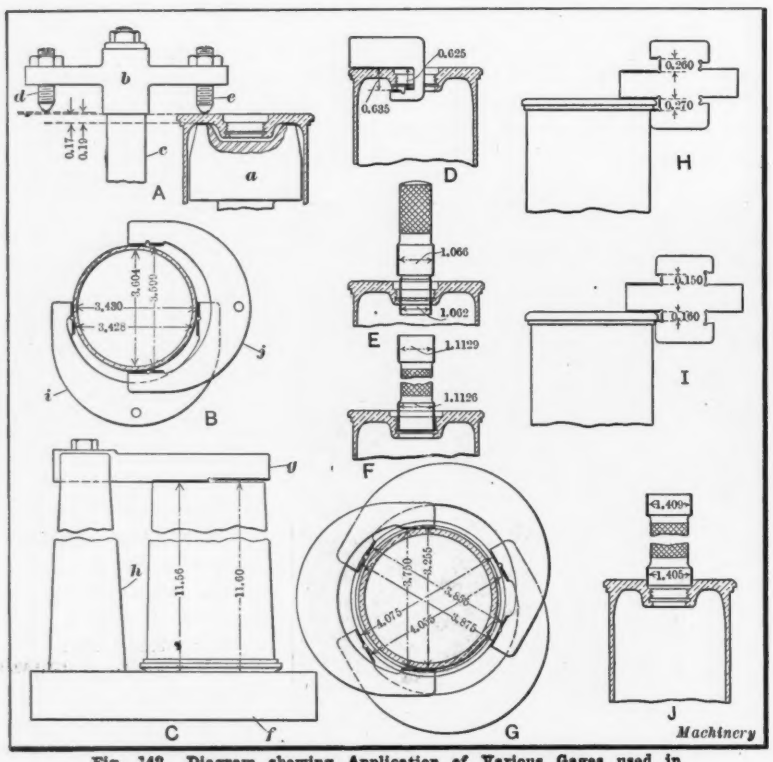


Fig. 142. Diagram showing Application of Various Gages used in inspecting 18-pound British Cartridge Cases

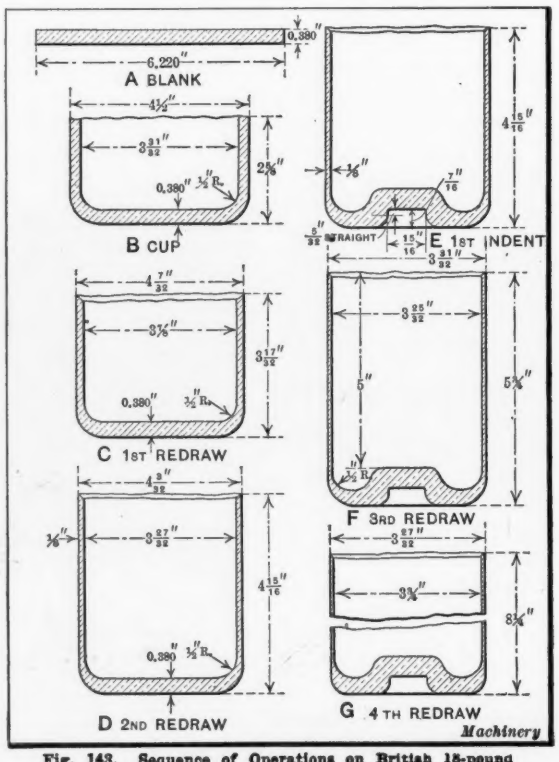


Fig. 143. Sequence of Operations on British 18-pound High-explosive Shell Cartridge Case

redrawing operation is now performed on a Toledo No. 856 press. The case, at this operation, is quite long and the production, of course, is somewhat reduced, being 120 per hour, with two operators. In the sixth redrawing operation the important dimension to retain is the thickness of the wall at the mouth; this should be 0.0285 inch. Following the sixth redrawing operation, the case is given a second trimming, as shown in Figs. 149 and 151. The production on the trimming machine is 350 cases per hour.

Heading

After the sixth redrawing and trimming operations the cartridge case is not annealed, but is taken directly to the Toledo heading press shown in Fig. 155. The operation of this press is quite interesting and is as follows: An indexing fixture fastened to the ram of the press carries two heading punches, one being used for forming the primer pocket and the other for flattening out the head. The heading die-holder retained on the bed of the press is also of the indexing type. By referring to Fig. 155, it will be noticed that die-holder *C* carries two different shaped heading dies *A* and *D*, each of which carries a bottom plug or support for the cartridge case. The method of operating is as follows: assuming that both dies *A* and *D* are empty, first place the cartridge case over the plug in the die, then index the turret die-holder *C*, bringing the loaded die in line with the punches. Next, index punch *B* in line with the cartridge case; after this, the press is operated and the first blow delivered. The die-holder now remains stationary and the punch-holder is indexed to bring the flattening punch in line, after which the press is again operated and the second blow delivered. An unheaded case is now loaded in the empty die, and the die turret indexed; this brings the unheaded case in line with the ram, and the headed case in line with the pick-up *E*. The punch-holder is now indexed to again bring punch *B* in line, and the press operated. While the blow is being delivered to the second case, the headed case is removed from the die turret by pick-up *E*. The production is 150 cases per hour. Following heading, the mouth of the shell is annealed previous to the tapering operations which follow. The annealing is accomplished in an interesting manner as shown in Fig. 154. The machine comprises a rotating table carrying twelve plates, which are also rotated, upon which the cartridge cases are placed. Twenty burners fed by natural gas are provided. The large dial makes two R. P. M., and in the meantime the cartridge cases are rotated continuously and at a much higher speed. This is accomplished by a simple, ingenious method. The main rotating fixture carries a large spur gear which meshes with small pinions fastened to the spindles of the plates that carry the cases; hence as the large fixture rotates the plates carrying

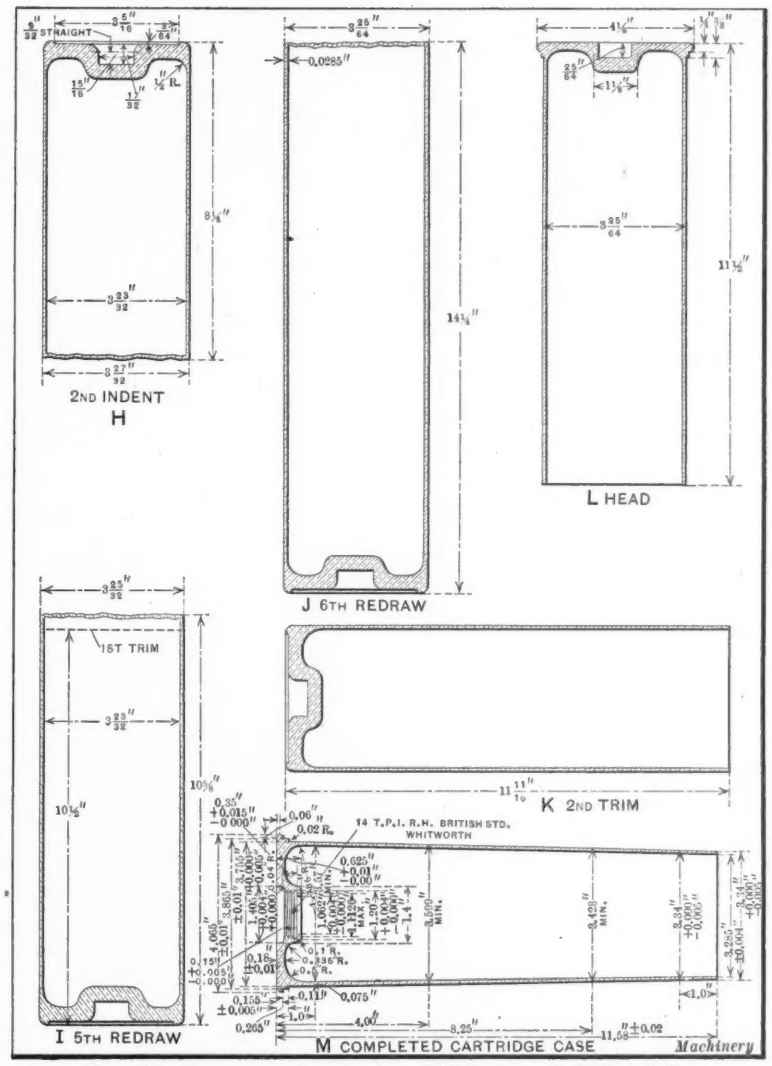


Fig. 144. Sequence of Operations on British 18-pound High-explosive Shell Cartridge Case—Continued (Thickness of Walls Slightly Exaggerated)

Fig. 145. Recording Instruments used in checking up Temperature of Annealing Furnaces

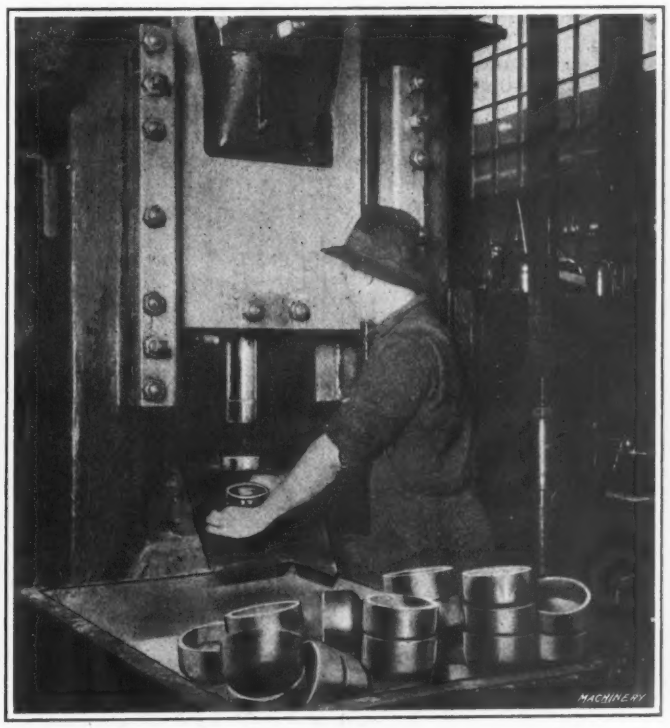


Fig. 146. First Redrawing Operation performed on a Toledo No. 59 Press

Fig. 147. First Indent on a Toledo Press

Fig. 148. Third Redrawing Operation on a Toledo No. 57 Press

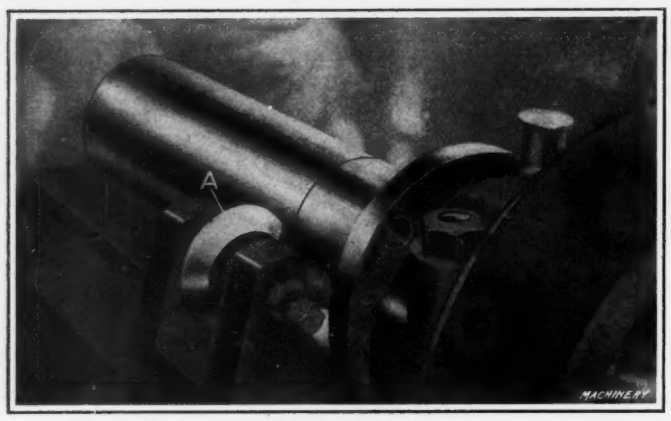


Fig. 149. Close View of Cartridge Case Trimming Machine shown in Fig. 151

the cases are also rotated. It requires two revolutions of the large table, or one minute, to anneal the mouth of the case sufficiently for tapering. The annealing temperature attained at this time is about 800 degrees F., which is sufficient to heat the cartridge cases to a cherry-red color.

Tapering

Following the annealing of the mouth of the case, two tapering operations are performed, bringing the case to the final shape shown at *M* in Fig. 144. These operations are performed in Toledo special tapering presses which are shown in Fig. 152. These machines differ from the ordinary punch press in that the stroke of the press is controlled by an eccentric and link motion instead of by a combined crank and toggle action. This mechanism is used owing to the length of stroke necessary and because of the fact that a press used for tapering does not need anywhere nearly the same amount of strength and power as one, for example, that would be used for heavy redrawing, embossing or forming operations.

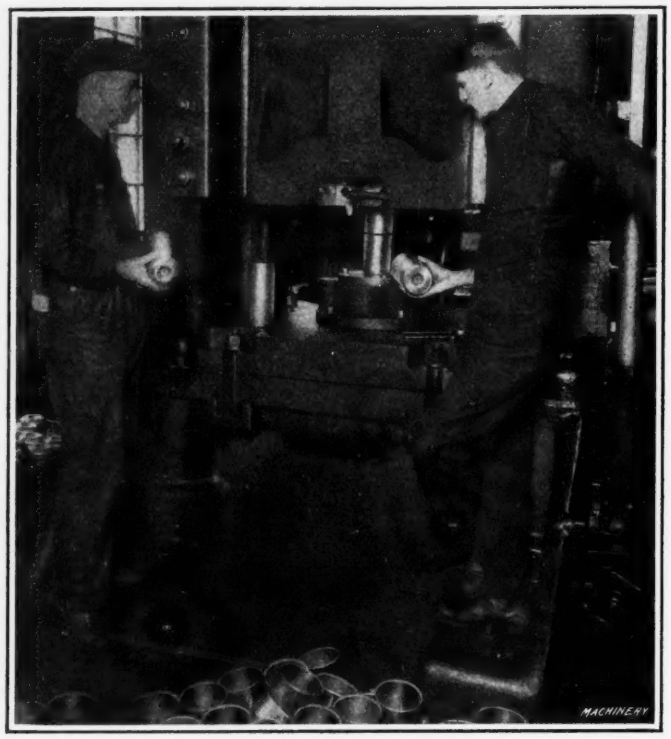


Fig. 150. Second Indenting Operation on a Toledo Press

In the first tapering operations, the mouth of the case is reduced to 3⅜ inches diameter and tapered for a distance of 6 inches, the diameter at the termination of the taper being 3⅝ inches. Two men are employed for this operation and the production is 250 per hour. In the second tapering, the

Fig. 151. Trimming Mouth End of Case on a Toledo Cartridge Case Trimming Machine

mouth of the shell is made straight for a distance of one inch and then tapered from there to the rim on the head at the rate of 0.04066 inch on the diameter for every inch in length. Two men can produce 250 cases per hour on this operation.

Machining Cartridge Cases

The cartridge case is not finished complete in the punch press, but after tapering, several operations are performed on the head and mouth, and these are handled on the Bullard cartridge case trimming, chamfering and facing machine

Fig. 152. First and Second Tapering Operations on Special "Toledo" Cartridge Case Tapering Machines

shown in Fig. 153. A description of this machine appeared in the April number of MACHINERY.

The operations are: first, rough-bore primer pocket; second, face head with facing tool; third, form with tool on rear of carriage; fourth, recess at bottom of primer pocket;

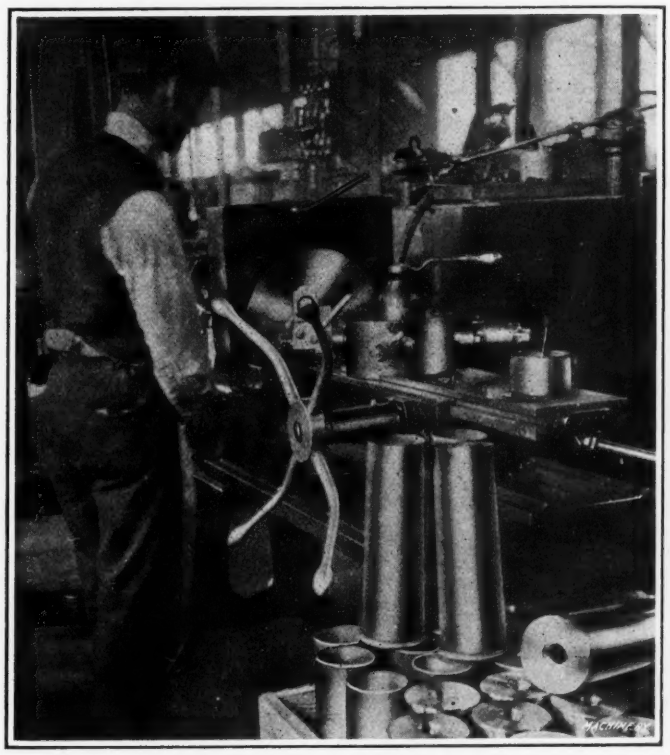


Fig. 153. Machining Head and Mouth Ends of Case on a Bullard Cartridge Case Trimming, Facing and Chamfering Machine

Fig. 154. Annealing Mouth in a Special Furnace previous to tapering

fifth, tap with Murchey tap—four threads per inch; sixth, ream with a combination reamer; seventh, turn and trim open end.

Inspecting and Testing

The cartridge case is now turned over to the inspectors, when the following gaging tests are made: First, gage for thickness of head; second, for tapers; third, over-all length; fourth, thickness through primer hole; fifth, primer hole diameter; sixth, root of thread; seventh, lower rim; eighth, thickness of head; ninth, thickness of head flange; tenth, diameter of counterbore at extreme head of case; eleventh, recess in pocket; twelfth, threads; and thirteenth, gun barrel test.

Fig. 155. Heading Cartridge Cases on a Toledo Press

The manner in which these inspection operations are handled is shown diagrammatically in Figs. 142 and 162 and in Figs. 156 to 161, inclusive. The first test that is made is for the thickness

Fig. 156. Gaging Thickness of Head of Cartridge Case

of head, measuring from the inside. This is accomplished as shown in Fig. 156 and diagrammatically at *A* in Fig. 142. The cartridge case is held on a post *a*, and the swinging arm *b* that rests on the shoulder of another post *c* carries two gag-

Fig. 157. Testing Taper of Cartridge Case with Horseshoe Gages

ing points *d* and *e*, one being set for the maximum and the other for the minimum dimensions. A limit of 0.002 inch is allowed.

The next inspection is gaging for taper. This is accom-

Fig. 158. Gaging Over-all Length of Case

plished by means of horseshoe gages, as shown in Fig. 157 and diagrammatically at *B* in Fig. 142. The upper gage *i* measures at a point 8.25 plus 0.000, minus 0.005 inch from the head and the lower gage *j* at a point 3.428 plus 0.000,

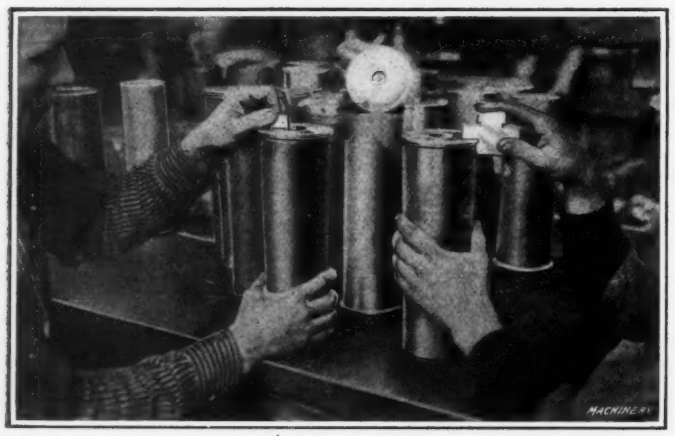


Fig. 159. Gaging Thickness of Head and Thickness through Primer Hole

Fig. 160. Gaging Diameter of Head and Depth of Counterbore

minus 0.002 inch from the head. The limit as shown at *B* is 0.002 inch for the smaller diameter, whereas the larger diam-

Fig. 161. Making Gun Barrel Test

eter has a limit of 0.005 inch. The third test is for over-all length as shown in Fig. 158 and at *C* in Fig. 142. Here the

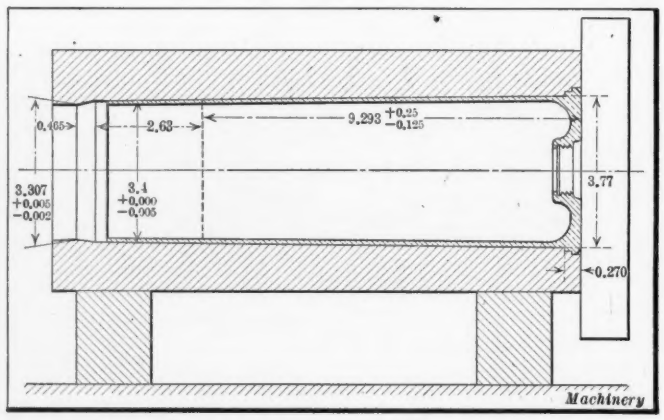


Fig. 162. Diagram showing Gage used for Gun Barrel Test

case is held on base-plate *f* and the gaging bar *g* is held on a standard *h*, a limit of 0.040 inch being allowed on the length.

The next test is shown in Fig. 159 and at *D* in Fig. 142.

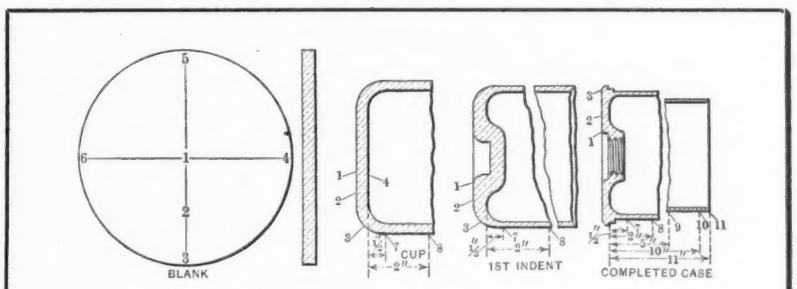
It consists in gaging the thickness from the head of the case to the inner face of the pocket. The allowable limit here is 0.010 inch. The hole for the primer is gaged as shown at *E* and *F* in Fig. 142. First, the clearance hole in the primer pocket is gaged as shown at *E*, afterward the root diameter of the threaded hole is tested as shown at *F*. Following this, the diameter of the head of the case is tested as shown to the right in Fig. 160 and at *G* in Fig. 142. Here the head is gaged at three different points as illustrated, the limits being as shown at *G* in Fig. 142.

The final gaging operations are shown at *H*, *I*, and *J* in Fig. 142, and in Figs. 161 and 162. The thickness of the head is gaged as shown at *H* and *I* in Fig. 142 and also to the right in Fig. 159. The gage used, shown at *H* and *I*, is of the double-ended type, so that the two thicknesses can be measured with one gage. The next test is to gage the diameter of the counterbore in the head of the cartridge case as shown at *J* in Fig. 142. Following this, the last and final test is made. This is the gun barrel test shown in Figs. 161 and 162. This gage comprises a cylindrical cast-iron tube, which is machined inside to the same dimensions as the bore of the barrel, as shown in Fig. 162, and two supporting stands. The cartridge case is pushed into this gage, and by laying a scale across the gage, the head of the cartridge case must come slightly below flush. The case should be easily inserted and extracted from this gage. This finishes the gaging operations.

Testing Cartridge Cases for Hardness

In order that the final product be according to specifications, it is imperative that each drawing and annealing operation be carefully followed. The method generally adopted by various manufacturers engaged in this work is to use the scleroscope and test the hardness of the case before and after each redrawing or annealing operation. Table VII gives the readings taken on the cartridge case after each operation, and the diagram with this table shows the points at which the readings are taken. It is the practice of this plant to "scleroscope" 1 per cent of its daily product; therefore, on a product of 4000 cartridge cases in ten hours, forty cases, after the completion of each operation, as shown in Fig. 163, are taken to the testing department where scleroscope readings are taken. These readings are then charted and compared with other tests.

TABLE VII. SCLEROSCOPE READINGS INDICATING HARDNESS OF METAL AFTER EACH ANNEALING AND REDRAWING OPERATION



Operation	Time of Test	Points at which Readings are Taken										
		1	2	3	4	5	6	7	8	9	10	11
Blanking	A*	15	14	14	14	15	14	..	..	..	..	..
Cupping	B	20	26	31	19	..	..	50	40	..	..	..
Annealed	A	12	12	12	11	..	..	13	12	..	..	..
First Redrawing	B	11	13	19	14	..	..	36	50	..	..	..
Annealed	A	12	12	12	11	..	..	12	11	..	..	..
Second Redrawing	B	12	10	12	..	..	..	36	50	50	..	..
First Indenting	B	34	35	22	..	..	..	44	44	46	..	..
Annealed	A	11	11	11	..	..	..	15	14	14	..	..
Third Redrawing	B	11	12	12	..	..	..	36	41	48	..	..
Annealed	A	10	11	12	..	..	..	12	14	15	..	..
Fourth Redrawing	B	11	11	12	..	..	..	31	38	44	..	..
Second Indenting	B	12	26	34	..	..	..	34	51	51	..	..
Annealed	A	10	11	12	..	..	..	12	14	14	..	..
Fifth Redrawing	B	14	12	15	..	..	..	32	35	41	41	..
Annealed	A	11	13	14	..	..	..	15	11	14	15	..
Sixth Redrawing	B	13	20	15	..	..	..	22	30	31	41	42
Heading	..	16	38	47	..	..	..	28	32	33	44	45
Mouth Anneal	..	16	38	46	..	..	..	26	30	31	22	12
Second Taper	..	16	37	46	..	..	..	35	38	44	36	59

Machinery

* Note: "A" is scleroscope reading before, and "B" after annealing.

Fig. 163. Testing Hardness of Cartridge Case with Scleroscope

MAKING PRIMERS FOR CARTRIDGE CASES

The percussion primer, carried in the head end of the cartridge case and used for igniting the propelling charge, comprises six parts, as shown in Fig. 164. Of these six parts, the body shown at *A* is the most difficult to make. This is made from 1 7/16-inch round bar stock, either in a hand or automatic screw machine. In one plant turning these parts out in large quantities, a Gridley 1¾-inch multiple-spindle automatic screw machine as shown in Fig. 165, is used for performing the first series of operations. The order of operations is as follows: first, rough-counterbore and form; second, drill and countersink; third, thread external diameter; fourth, finish-ream, cut off and feed stock. The spindles of the machine are rotated so as to give a speed of 90 surface feet for the forming cut. The production is sixty per hour.

The second operation on the body consists in facing and shaving the head. This is done on a hand screw machine of the Pratt & Whitney type. The work is rotated to give a surface speed of 125 feet per minute, and the production is 120 per hour. The third operation is milling the key slots in the base in a Brown & Sharpe hand milling machine, using a simple indexing fixture. The end-mill which is used is operated at 200 feet surface speed, and one cut finishes each slot. The production is 140 per hour. The fourth operation is reaming the tap hole and the smaller hole in the base of the body. This is done in a Henry & Wright two-spindle drilling machine carrying a combination reamer. The work is held in a fixture which can be slid along the table, being controlled in its movement by guide strips fastened to the table. Two tools are used, one for roughing and the other for finishing, the surface speed being about 200 feet. The production on this operation is about 150 per hour.

The fifth operation is to tap the small hole in a tapping machine with a tap operating at a surface speed of 30 feet per minute. The work is held in a jig and the production is 120 per hour. The sixth operation is to finish-ream the percussion cap hole in a Henry & Wright drilling machine. This is a very difficult operation to accomplish because the accuracy required is ± 0.0005 inch. The surface speed of the tool has to be cut down to 80 feet; and the production is 100 per hour. The seventh operation is to stamp the required letters on the base of the prim-

er with a hand stamp, three sets of stamps being required. The production is 150 per hour. The eighth is to lacquer the interior with a brush. The lacquer used consists of: seedlac, 10.53 per cent; turmeric, 5.26 per cent; spirits, methylated, 84.2 per cent. This is done at the rate of 200 per hour. The ninth operation is inspecting.

Making the Disk, Anvil and Plug

The closing disk *B*, Fig. 164, for the primer is made from 1-inch diameter brass rod in a 1¼-inch Gridley multiple-spindle automatic screw machine. The order of operations is as follows: first, form and cup; second, shave; third, finish cup; fourth, cut off and feed stock. The stock is operated at a surface speed of 110 feet, and the production is at the rate of 24 seconds a piece. The second operation is to remove the burrs on a small stand grinder. The third operation is to slit and straighten in a small Brown-Boggs punch press. The fourth is to inspect.

The anvil *C*, Fig. 164, is made on a No. 00 Brown & Sharpe automatic screw machine from ⅜-inch round bar stock. The order of operations is: feed stock to stop; form and bore; ream small hole; thread and cut off; burr in the burring attachment. The stock is rotated at 1800 R. P. M. for forming and at 900 R. P. M. for threading. The production is 300 per hour. The second operation is slotting, which is accomplished in a National-Acme screw slotting machine as shown in Fig. 167. The production is about 400 per hour. The third operation is drilling, which is accomplished in a Leland-Gifford high-speed drilling machine as shown in Fig. 166. The drill used is size No. 55 (0.052 inch) and is operated at 10,000 R. P. M. An indexing fixture is used, and it requires three indexes to complete the drilling. The production is 400 per hour. The fourth operation is inspecting.

The plug *D*, Fig. 164, is also made on a No. 00 Brown & Sharpe automatic screw machine from ⅜-inch round bar stock. The order of operations is: feed stock to stop; form and groove; thread; cut off; burr with burring attachment. The spindle speed is 1800 R. P. M. The production is 450 per hour. The three fire holes are also drilled in the Leland & Gifford high-speed drilling machine shown in Fig. 166, using an indexing attachment. The drill is operated at 10,000 R. P. M., and 400 per hour are turned out. A different jig is used for drilling the plug from that used for the anvil. In the case of the plug the holes are drilled parallel with the axis, and in the anvil at an angle of 26 degrees with the axis. The percussion cap *E*, Fig. 164, is made in a small punch press in one operation, a combination blanking and cupping punch and die being used. The soft copper ball *G* is a standard product of the ball manufacturers.

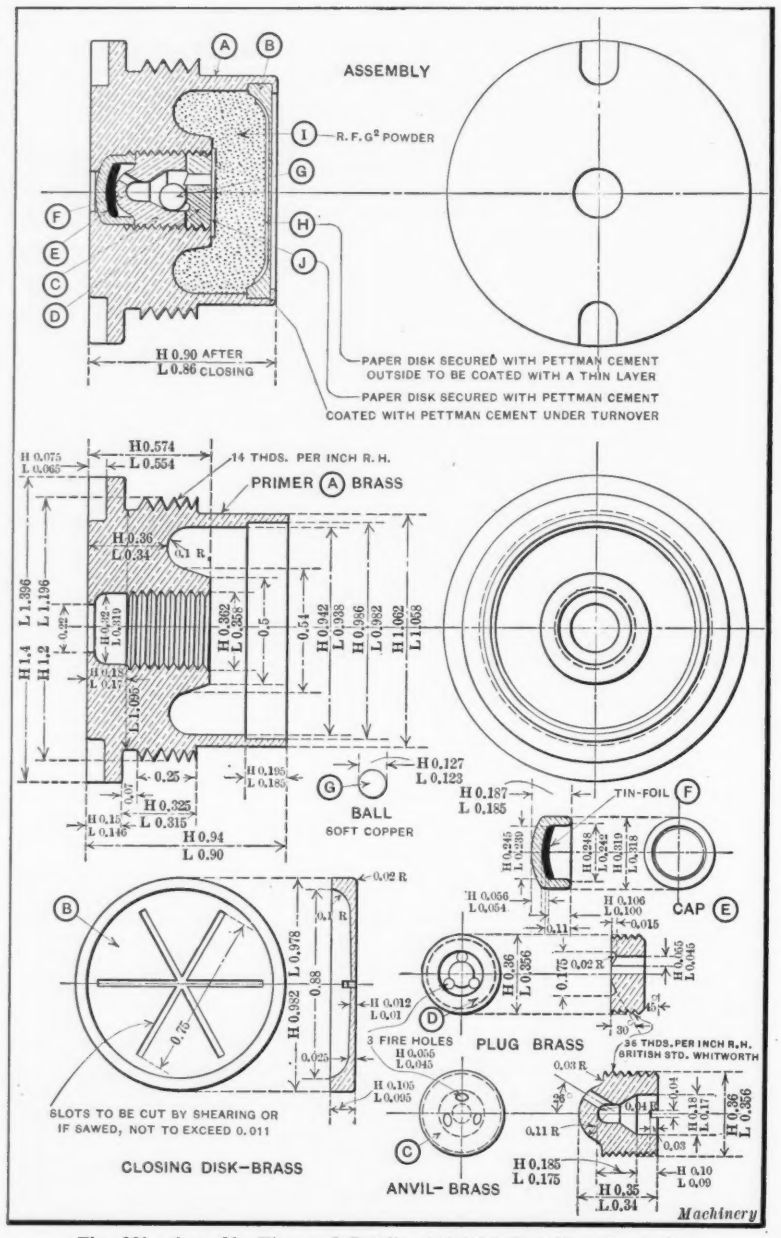

ASSEMBLY
R. F. G² POWDER
PAPER DISK SECURED WITH PETTMAN CEMENT OUTSIDE TO BE COATED WITH A THIN LAYER
PAPER DISK SECURED WITH PETTMAN CEMENT COATED WITH PETTMAN CEMENT UNDER TURNOVER
H 0.90 AFTER CLOSING
L 0.86
PRIMER (A) BRASS
14 THDS. PER INCH R. H.
BALL
SOFT COPPER
TIN-FOIL (F)
CAP (E)
SLOTS TO BE CUT BY SHEARING OR IF SAWED, NOT TO EXCEED 0.011
CLOSING DISK—BRASS
3 FIRE HOLES
PLUG BRASS
36 THDS. PER INCH R.H. BRITISH STD. WHITWORTH
ANVIL—BRASS
Machinery

Fig. 164. Assembly View and Details of British Cartridge Case Primer

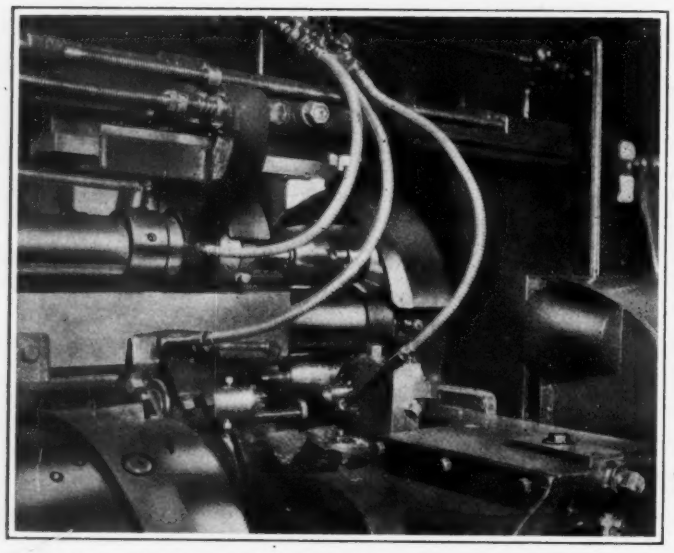


Fig. 165. Machining Cartridge Case Primer Body on a Gridley 1¾-inch Automatic

Assembling and Loading

Up to the present time few of the manufacturers that have taken orders for primer parts are assembling and loading them. This delicate and somewhat dangerous operation is generally handled in the government arsenals or in cartridge factories regularly devoted to this work. Manufacturers that have taken orders for complete rounds of ammunition, however, may be called upon to handle this work in the future, so a brief review is given of the loading and assembling operations.

In the preceding description, the methods used in manufacturing the various parts of this primer have been described, but before any of the parts can be assembled the copper cap *E*, Fig. 164, must be charged. This cap, as previously mentioned, is made

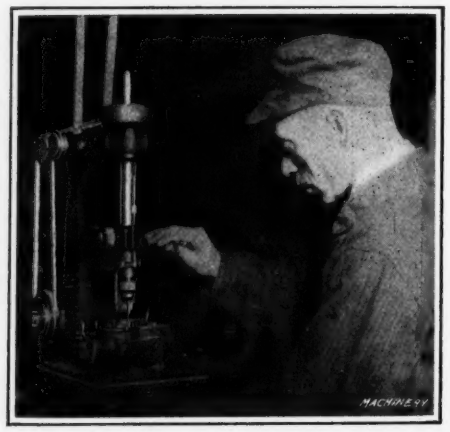


Fig. 166. Drilling Fire-holes in Anvil in a Leland-Gifford High-speed Drilling Machine

on a double-action punch press, and is blanked and cupped in one operation. After cupping, it is cleaned, dried and then varnished with a varnish containing the following constituents: finest orange shellac, 20 per cent; spirits (methylated), 80 per cent. The next operation is charging the cap with 1.2 grain of the following explosive composition:

Constituent	Parts (by weight)
Sulphide of Antimony.	18
Chlorate of Potash....	12
Glass (ground)	1
Powder (mealed)	1
Sulphur	1

For charging, the caps are held on one plate, and a second plate called a "charger," having the same number of holes as the cap plate, is located over the caps, and the explosive charge held in the plate is deposited in the cap. The cap plate is then taken to what is called a fulminate pressing press, where the charge in the cap is compressed by means of punches under a pressure of 800 pounds. The next step is to prepare sheets of tin foil which are lacquered on one side with the following composition: seedlac, 10.52 per cent; turmeric, 5.26 per cent; spirits, methylated, 84.22 per cent. Disks are then cut out from this tin foil and pressed into the cup under 400 pounds pressure, the lacquered side outward. The primer cup is then varnished with the same varnish as that used on the cap previous to charging. The cap is now coated externally with Pettman's cement which is composed of the following ingredients:

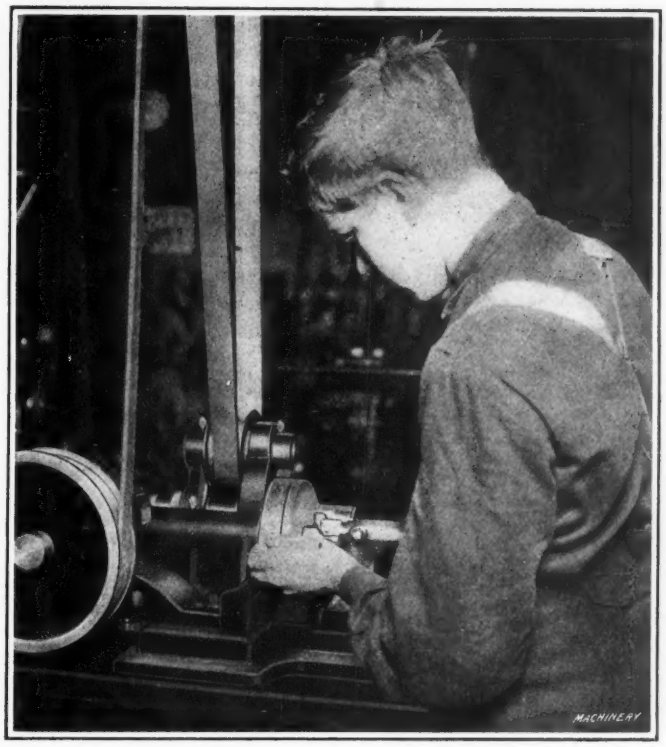


Fig. 167. Slotting Anvils in a National-Acme Screw Slotting Machine

Ingredient	Per Cent
Gum Shellac	18.18
Spirits, methylated...	19.39
Tar, Stockholm	12.12
Red, Venetian	50.31

The primer is now ready for loading, and the first part to be assembled is the cap *E*. Before this is placed in body *A*, however, the pocket in the latter is coated with Pettman's cement. The parts are then put in, in the following order (see Fig. 164): cap *E*, anvil *C*, soft copper ball *G*, and brass plug *D*. Plug *D* is locked in place by three small punch blows, after which the fire holes are covered with a paper disk *J* that is secured with Pettman's cement. The primer cavity is now filled with R. F. G² powder, and brass closing disk *B*, with paper disk *H* attached to the inner surface by Pettman's cement, is then put in place. This is finally held in place by spinning over the edge of the primer body, as shown in Fig. 164. The last operation is to coat the outer surface of disk *B* with Pettman's cement, after which the primers can be turned over to the inspectors.

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AS THE great European war drags on, the need of shells and still more shells, becomes more and more insistent. How many have been used is not known—we simply guess that the number is enormous. In August, 1914, the German army had six cannon for each thousand infantry and cavalry and 6000 shells for each gun. On the basis of 4,000,000 first and second line troops liable to call to the colors, this means over 140,000,000 shells ready for all classes of artillery when war was declared. But even the foresight of the German military experts who had devoted years to planning and preparation apparently had not provided adequately for millions of men fighting for months on battle lines extending hundreds of miles. An American army officer who has given the matter considerable thought, estimates that the consumption of shells by the German army has been three times the number on hand at the outbreak of the war. The Allies have had to meet this condition of preparedness as best they could by utilizing the resources of private manufacturers, with the result that the metal manufacturing world, other than the Teutonic nations, is largely engaged in the business of shell making, or manufacturing machinery for the purpose.

The design and construction of high-explosive shells used by the different nations differ in details and explosives used; but the primary object is the same for all—to demolish trenches, earthworks, and fortifications. While shrapnel is fired with awful destructive effect upon troops in open formation, it is of little use when the enemy is concealed behind earthworks or in trenches. Then the shell that bursts on impact and blows the defenses into fragments is needed.

Because of the enormous number of shells being made in the United States and Canada, the structure and manufacture of these deadly missiles have become legitimate engineering subjects, and this number of MACHINERY is partly given up to a treatise on the manufacture as studied in many Canadian and American plants. Modern war is replete with engineering problems, and not the least is the manufacture of ammunition. The grim events of the past year in the theater of war have given many serious concern as to what would be the fate of this nation, unprepared as it is, if suddenly attacked by a powerful and unscrupulous foe. The response of private plants in this crisis of the Allies has shown that in them our government has resources not realized by the champions of national defense. In presenting these articles we have helped, we hope, to make that private arm still more effective for preserving national peace.

* * *

AS EVERY one knows, the demand for machine tools and other metal-working machinery used in the making of munitions has never been so great as now, because the prosecution of modern war depends as much on the making of guns and ammunition as on the movement of armies and navies. Few, in America at least, anticipated that a great war would resolve into such a gigantic engineering enterprise, and that the machinery of shops, mills and factories would be so vitally necessary to its successful prosecution. But the fact is keenly appreciated now, and while the battle rages in Europe the shops in America hum with the sound of making shrapnel, shells, guns, powder and cartridges. The whole manufacturing world is the workshop for the armies of Europe, and the output has not yet equalled the demand.

With this enormous demand for American machinery has come the temptation to scamp work and charge high prices. Lathes used only for turning shrapnel or high-explosive shells need not be necessarily as perfect in alignment as when made for general purposes; and when munition plants in America and Europe are clamoring for machinery, the inspectors must be less rigid in testing them. If under these conditions any of our manufacturers fill their orders with an inferior product for which they charge fifty or seventy-five per cent more than good machines were sold for before the war, such a policy will react against them when normal conditions again prevail. Would it not be wiser to build "turning machines," with no pretensions of possessing high-grade qualities and sell them as such, than to work them off as the regular high-grade product that has won recognition the world over for excellence? The war will not last forever; normal conditions will surely return, and when they do return manufacturers who have filled their war orders with machines up to the high standard of reputable American machine tool builders will have no regrets—no shameful records that they will wish obliterated. Most of our manufacturers belong in this class; but those who have been less scrupulous will suffer in reputation and pocket, and with them will suffer the reputation of our machine tool industry as a whole.

* * *

A FEW builders of motor trucks have provided covers to protect the driving chain and sprockets with the idea of lengthening the life of these vital members of the drive. The importance of protecting chain drives has been referred to in these columns before, but in previous articles the principal reason advanced for protecting the sprockets and chain was to increase mechanical efficiency. Recent accidents in New York and other cities have shown that there is a great need of chain-cases for the protection of pedestrians. Several deaths have occurred within the past year as the result of persons stumbling and falling into the driving chains of motor trucks and being mangled.

The possibility of such terrible accidents is obvious when once pointed out, although we seldom consider the unprotected parts of moving vehicles dangerous to pedestrians. In crowded cities, conditions differ essentially from those in the country, and the possibility of having one's garments drawn into the chain-drives of a passing vehicle is apparent.

The probability is that state laws will have to be passed requiring users of motor trucks having chain-drives to protect them, to insure the safety of pedestrians. Such legislation will necessitate the employment of designers to solve the problem which has been brought to their attention many times in the past. The problem of protecting the chain-drive of a motor truck is a peculiarly awkward one because of the shape, size and arrangement of its members, and the necessity, oftentimes, of quickly getting at the working parts. It cannot be solved in any makeshift manner. The parts must be properly designed for strength, lightness and durability. When treated as an engineering problem, the difficulties will disappear; but they will not disappear until designers of ability have turned their attention to it.

LETTERS ON PRACTICAL SUBJECTS

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TURNING SINGLE-THROW CRANKS

The difficulty experienced by school boys in making and using the ordinary style of dogs for turning single-throw crankshafts for gasoline motors led the writer to devise the method illustrated and described herewith. The style of dog shown in MACHINERY'S Operation Sheet No. 56 was first tried, but it soon became evident that this plan presented too great difficulties for the use of second-year boys in our day school. This applied both to the making of the dogs and to the setting up of the work, and even when adjusted with the aid of a surface gage an accidental dig of the tool would undo all the setting. The following method was finally devised and gave very satisfactory results.

Two blocks of mild steel were planed all over to a suitable size and centers were located representing the throw of the crank. Holes were then rough-drilled on these centers to somewhat less than the required size. The blocks were next clamped together and set up on a lathe to have the holes finished. The next step was to turn up a pair of parallel steel studs to fit the holes in the blocks, after which the blocks were mounted on the table of a milling machine with the studs resting on a pair of parallels as shown in Fig. 1.

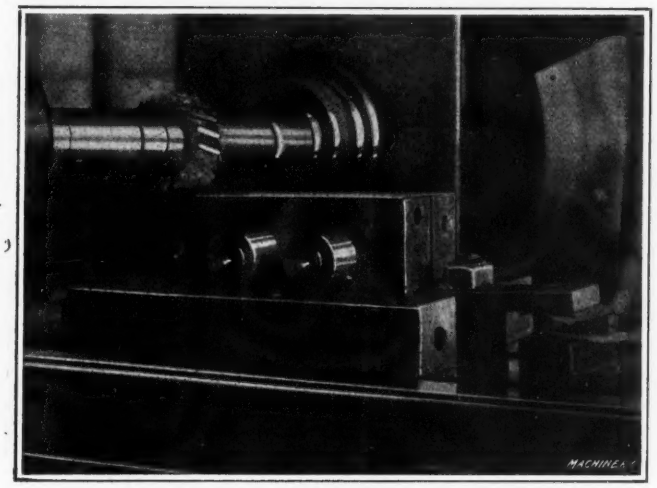


Fig. 1. Milling Blocks to bring Sides Parallel and Holes Central

Pieces of paper were put under the studs to make sure that the blocks were not tilted while the clamps were being tightened. After the work had been set up in this way, a cut was taken over the top surface of the blocks and then, without altering the vertical adjustment of the table, the blocks were turned over and reclamped so that the opposite sides could be milled. This insured having the sides of the blocks parallel and the holes centrally located.

Short steel plugs centered on one end were now fitted tightly into one hole in each block and pinned in position. These plugs provided for mounting the work on centers for turning the crankpin, and if a number of crankshafts had to be turned it would be desirable to make the plugs of tool steel so that they could be hardened. Set-screws were then fitted into the blocks for use in holding the crankshafts securely in place. Fig. 2 illustrates the method of setting the dogs on the crankshafts ready for performing the turning

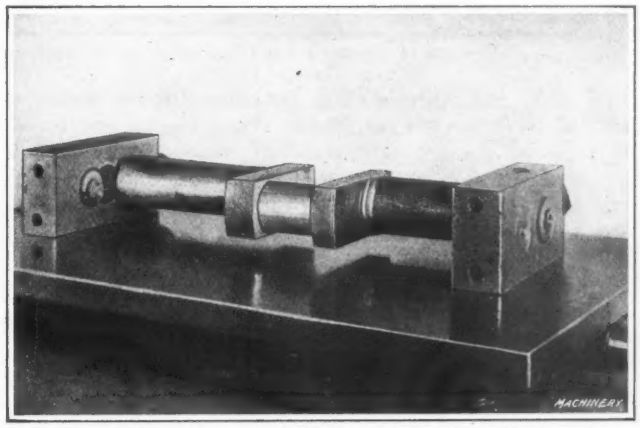


Fig. 2. Setting Dogs on Crankshaft ready for Turning Operation

operation, or for testing to make sure that the setting had not been disturbed during the machining operation. It will be seen that the crankshaft is laid on a surface plate with the dogs in position so that the slightest alteration in the setting can easily be determined. While this method of mounting the work for the turning operation involves some unnecessary labor in making the dogs, it was easily carried out and the risk of producing defective work was greatly diminished.

Christchurch, New Zealand. JOHN PEDDIE

MACHINING THE BAND GROOVES IN SHRAPNEL SHELLS

The fixture described in this article is attached to an ordinary engine lathe as shown in Fig. 1, and provides for machining the "waves" in the band groove of shrapnel shells. The chuck is made large enough to take shells up to 6 inches in diameter. A 60-tooth bevel gear is secured to the chuck and the number of "waves" is easily varied by changing the ratio of the bevel gear drive between the chuck and the carriage. A casting is fitted over the vees of the lathe bed at the front of the headstock, and this casting has a boss in the center which carries the eccentric shaft to which the bevel pinion is keyed. This shaft transmits motion to the saddle by means of a connecting-rod which runs down the center of the lathe bed below the stay and is bolted to a cross-plate on the front of the saddle.

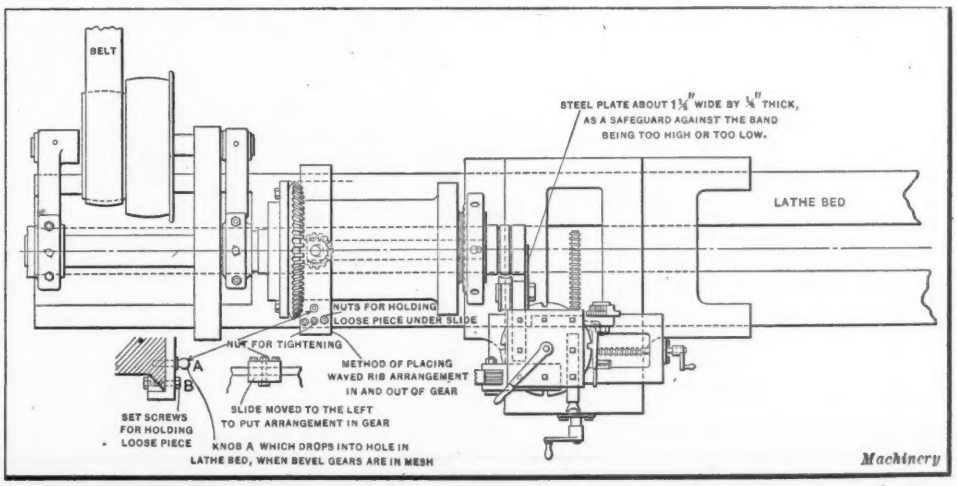

BELT
STEEL PLATE ABOUT 1¼" WIDE BY ¼" THICK, AS A SAFEGUARD AGAINST THE BAND BEING TOO HIGH OR TOO LOW.
LATHE BED
NUTS FOR HOLDING LOOSE PIECE UNDER SLIDE
NUT FOR TIGHTENING
METHOD OF PLACING WAVED RIB ARRANGEMENT IN AND OUT OF GEAR
A
B
SET SCREWS FOR HOLDING LOOSE PIECE
SLIDE MOVED TO THE LEFT TO PUT ARRANGEMENT IN GEAR
KNOB A WHICH DROPS INTO HOLE IN LATHE BED, WHEN BEVEL GEARS ARE IN MESH
Machinery

Fig. 1. Lathe equipped with Attachment for machining "Waves" in Band Grooves of Shrapnel Shells

A toolpost which carries four tools made of high-speed steel is mounted on the cross-slide. The cycle of operations, shown in Fig. 2, is as follows: First, chuck the shell and bring

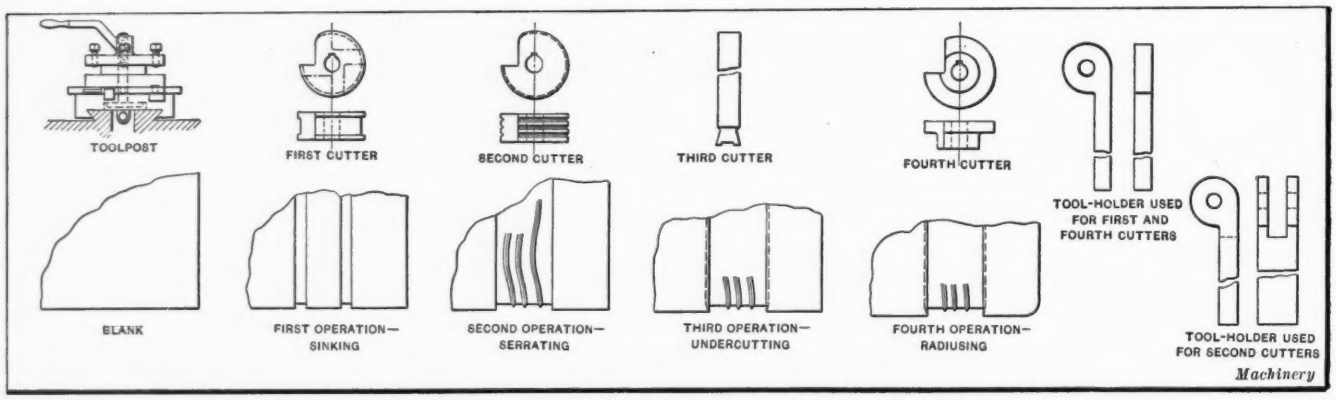


Fig. 2. Cycle of Operations performed in machining Band Groove, and Tools used for Successive Operations

cutter No. 1 into position ready for sinking the groove to the required depth for the serrations. Two grooves are cut with the required amount of metal left between them for the serrations. A stop used in connection with this cutter provides for obtaining exactly the required depth for the groove. Second, bring cutter No. 2 into position and move the saddle forward to engage the special geared drive. Then enter the locating pin *A* into its hole and at the same time screw up the clamp nut *B* to give the required "wave motion" to the saddle and leave the compound rest free.

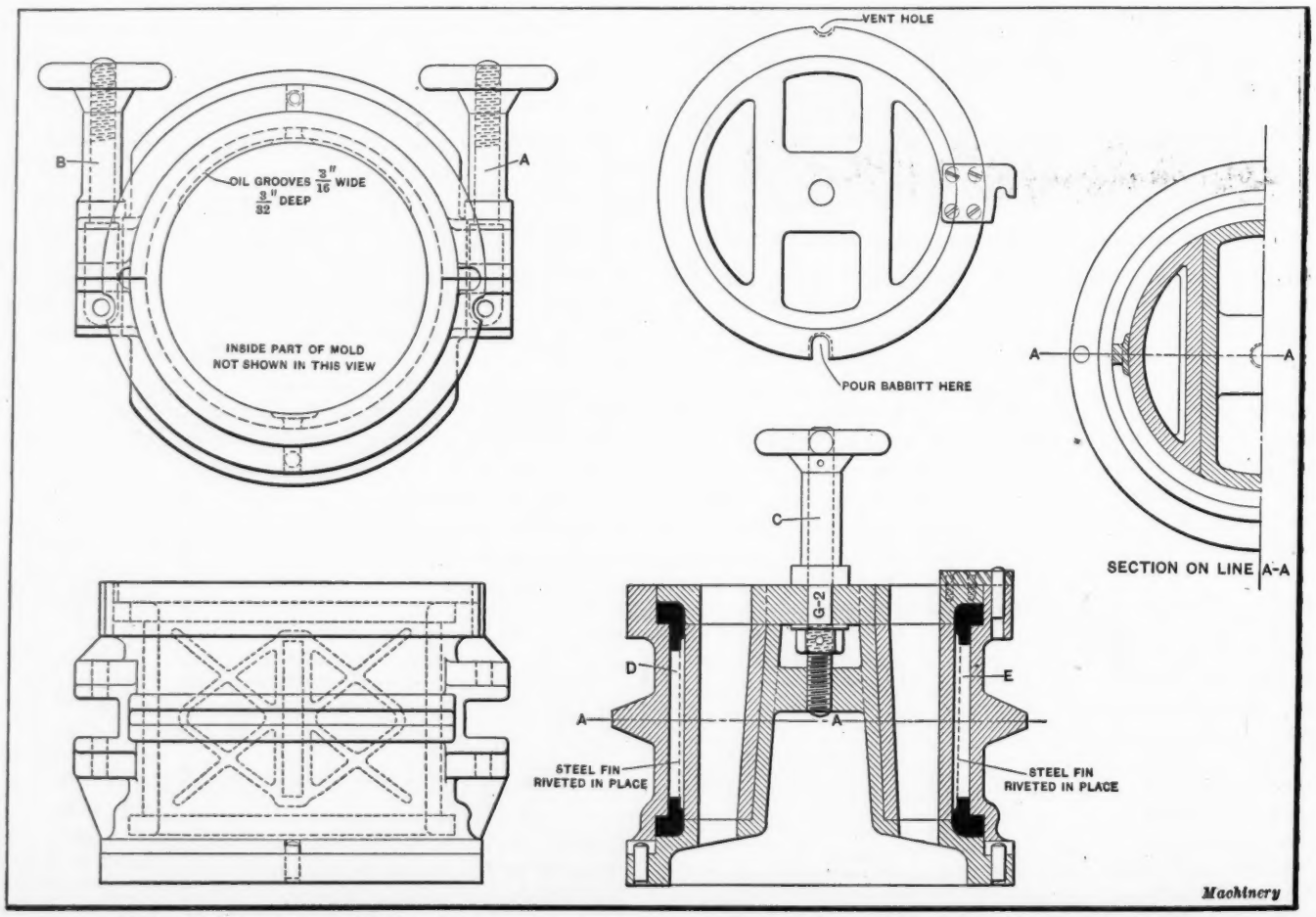
After the waving tool has been fed in to the depth reached by the tool for the first operation, the locating pin *A* is withdrawn and the saddle moved back sufficiently to disengage the gears. Third, bring around the third cutter and make the required under-cut at each side of the groove. Fourth, bring the last tool into the working position and round off the end of the shell. We have been using this device exclusively in the manufacture of different sizes of shrapnel shells, and found that it was possible to finish 100 shells a day on each machine. A feature of the attachment is that it enables the entire job to be finished at a single setting.

Sheffield, England. J. W. GEARY

MOLD FOR BABBITTING CONNECTING-ROD BEARINGS

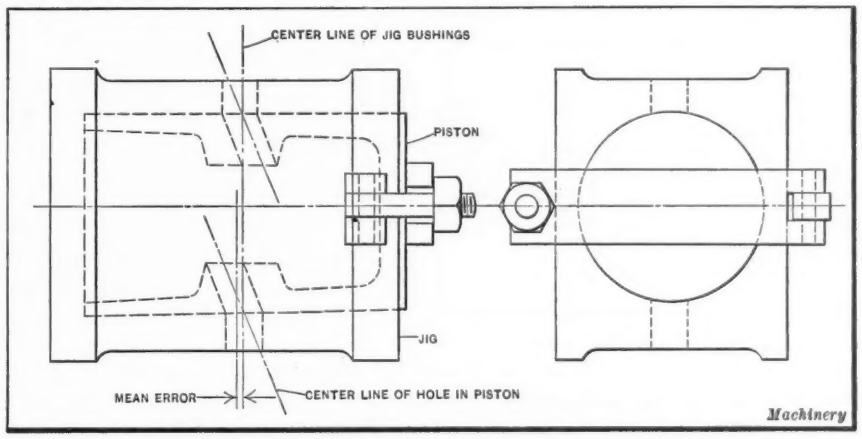
It is the purpose of this article to describe a babbitt bearing mold which was designed for use in making connecting-rod bearings. The accompanying illustration shows the mold in plan and elevation, together with a vertical cross-sectional view, a horizontal cross-section of half the mold, and a plan view of the cover plate. It will be seen that the body of the mold consists of two parts which are clamped together by the bolts *A* and *B* and tightened by means of star-wheels; and that the cover plate is held down by a third bolt *C*. The arrangement is such that the mold can be operated very rapidly, and as the castings are cored out to provide the maximum radiating surface, the babbitt cools in a short time after it has been poured. Lack of adequate radiating surface is often a serious fault of babbitting fixtures.

The babbitt bearing is cast complete so that it is ready to be machined; and the oil grooves are formed in the mold so that scraping is the only operation necessary on the inside. Steel fins shown at *D* and *E* are mounted in the mold to divide the bearing into halves, but these fins leave sufficient babbitt at each end to form a connection which



Bearing Mold in which the Babbitt Liner is cast in One Piece for Convenience in machining, and then split ready for Use

holds the two parts together, so that the bearing can be mounted on a mandrel while the outside is being machined. The fins are riveted to two castings which fit against the taper shells, as shown in the cross-sectional view. Thus it is possible to lift them out with the bearing, so that the steel fins can be easily removed. M. W. W.



The Way in which Trunnion Holes in Pistons were out of Alignment when drilled in an Accurate Jig

BORING MILL KINKS

To bore a long straight hole on a boring mill is about as ticklish a job as a machinist can find, especially where the mill is used for all sorts of work and the rams are changed from day to day. I have had to bore holes from two to four feet long with only 0.002 inch variation. The quickest way to bore a hole like this is to set the ram over as close as possible, which will be a few thousandths inch off one way or the other. Then, instead of losing time and patience trying to set the ram exact, just put a shim under the saddle on the cross-rail and you will get the proper variation one way or the other. This "stunt" is so useful that if I had a shop of my own with a boring mill, I would put one set-screw on each side of the saddle, coming in touch with the gibs, so I could raise either side without using shims. This same method could be used for turning a job on the mill or planing down the side with the top head of the planer.

Wausaukee, Wis. W. E. BUTLER

AN ACCURATE JIG THAT PRODUCED INACCURATE WORK

If the work produced with a jig is inaccurate, the chances are that the jig is to blame, but this is not necessarily the case. A strange instance of this kind came to my attention some years ago in which a carefully made jig for use in drilling the trunnion holes in pistons was returned to the toolmaker for the purpose of having errors corrected which were supposed to exist in the tool. A careful inspection failed to disclose anything more than minute inaccuracies and the jig was sent back to the machine shop with a report that it was O. K. But pistons drilled in the jig failed to pass inspection and the tool was finally sent back with orders to remake it. Acting upon these instructions, the holes were rebored and new bushings and clamps were provided, after which the jig was again sent to the manufacturing department. After doing all this work, however, there was no improvement in the accuracy of the pistons.

Different machinists were assigned for this operation and the jig was used on different machines, but the result was always the same—the pistons produced in the jig ultimately found their way to the scrap pile. After several conferences had been held and a lot of time lost, someone tried drilling the trunnion holes at a lower speed and finer feed, with the result that all the pistons drilled under these conditions were found to be quite accurate. This showed that the cause of the trouble lay in the operation card which specified the speed and feed at which the work was to be done, and not in the jig, on which much of the blame had been laid.

The explanation of the way in which the error was produced in the work lay in the fact that under the excessive speed and feed which had originally been specified, there was a tendency for the drilling to "run out." This effect was further increased by the springing of the work under the heavy feed pressures. The maximum error in the jig was not over 0.001 inch, but owing to the inaccuracy resulting from the excessive speed and feed, the error in the work averaged 0.006 inch. The accompanying illustration exaggerates the manner in which the error occurred; the location of the holes at the surface was correct, but the holes were out of line. Line-reaming the piston after removal from the jig brought the holes into alignment, but the line of the holes was not perpendicular to the axis of the piston.

Brooklyn, N. Y. F. J. BADGE

TOOL FOR CUTTING TEST BARS

The cutting of test bars from solid steel stock is a difficult operation, but the greatest trouble is likely to be experienced in cutting off the bar at the bottom after the trepanning operation has been completed. The accompanying illustration shows a tool for cutting test bars which has given very satisfactory results. The body of this tool has a hole *A* running through it of the diameter of the test bar which is to be cut, and a second hole *B* of suitable size to receive the tool-bar *C*. This bar is slotted to receive the cutter *D* which is held in place by a set-screw. The feed lever *E* is secured to the opposite end of the tool-bar by means of a pin or set-screw, and the feed-screw *F* is carried by a lug on the body of the tool. Tightening up the screw *F* results in rotating the feed-bar by the engagement of this screw with lever *E*; the coil spring *G* is provided to eliminate backlash. It will be evident that the tool itself is turned by means of the crank handle *H*. After the trepanning operation has been completed, the cutter *D* is fed in to a depth of 3/16 inch in the case of a test bar 13/16 inch in diameter, and after the tool has cut to

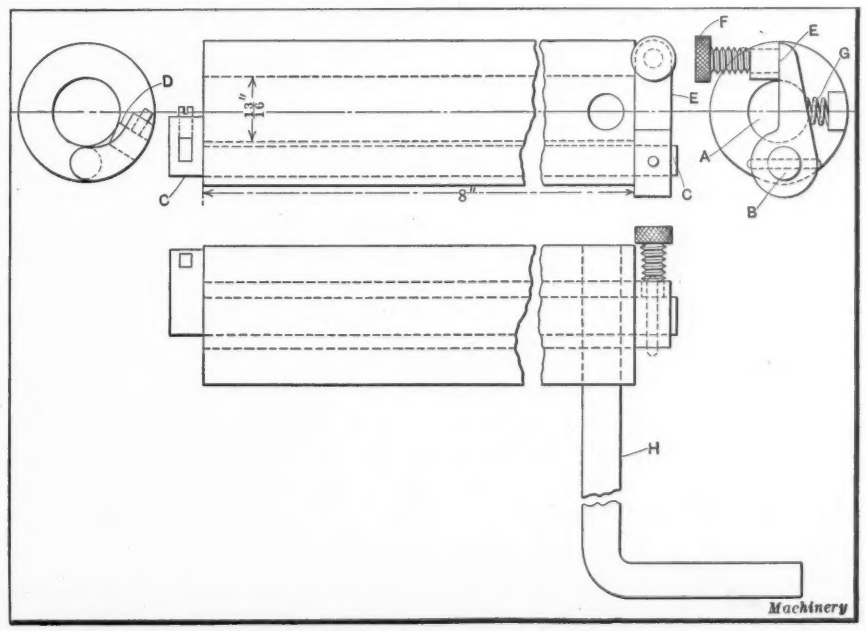
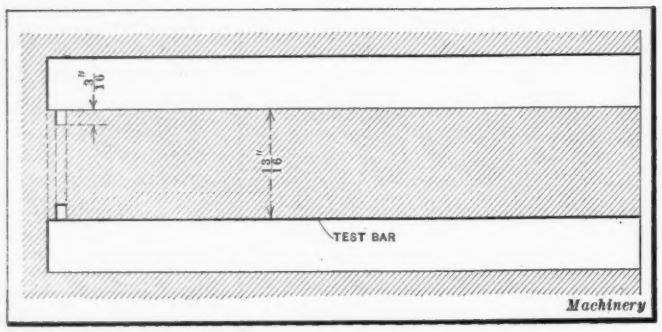


Fig. 1. Type of Trepanning Tool used for cutting out Test Bars from Solid Stock

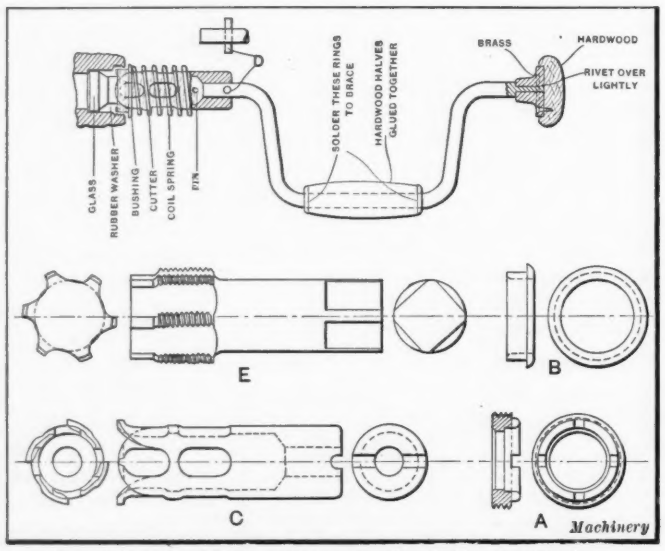


this depth the bar can be easily broken off. To withdraw the tool from the work, it is merely necessary to release the feed-screw *F* until the feed-lever comes to the starting position, which is determined by a stop carried on the body of the tool. In case the feed-lever fails to come into contact with this stop, the whole tool is turned backward to remove the chip or other obstruction which is holding the tool.

Milwaukee, Wis. GUS LUCK

REMOVING RUBBER GASKETS FROM LUBRICATORS

The accompanying illustration shows a tool for use in removing rubber gaskets from sight-feed lubricators on locomotives. A cross-sectional view of the lubricator is shown at the top of the illustration with the tool in the operating position. Trouble is sometimes experienced in removing the old gasket when it is necessary to substitute a new one, but by using the tool which the writer developed for this purpose, the work can be done quite easily. The method of procedure is as follows: After the jam-nut *A* has been removed, the casehardened bushing *B* is substituted to prevent injuring the threads in the lubricator. The spring provided on the tool serves to hold the bushing in place. The cutting edges of the tool *C* are of a larger diameter than the bore in the bushing, so that it is necessary for the bushing to be slipped over the cutter from the back before the tool is assembled ready for use.



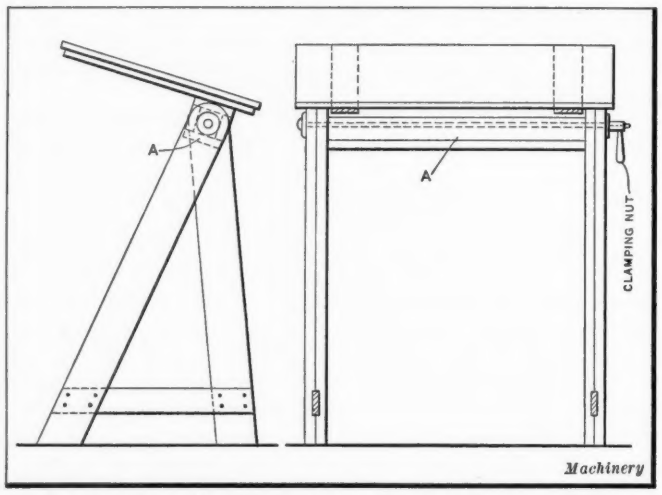
Special Brace and Tools used for removing Rubber Gaskets from Sight-feed Lubricators

It will be seen that the cutter is driven by a pin *D*, which is 3/16 inch in diameter; this pin is fitted into the end of the brace and enters the groove in the end of the tool *C*. The tap *E* is provided for tapping the threads in the lubricator when it is necessary to refinish them. A special brace is designed for this work as shown in the illustration.

L. K.

ADJUSTABLE DRAWING TABLE

The accompanying illustration shows an adjustable drawing table which the writer made for his own use some time ago. As this table has been found very satisfactory, and as it is inexpensive to make, it may prove of interest to some readers of MACHINERY. It will be evident from the illustration that the drawing board may be readily set to any required angle, as the uprights have no fixed tie between them except the cross-rail *A*, so that adjustment is provided to enable the feet to find a bearing on uneven floors. The cross-rail is probably the only part which may not be clearly understood after looking at the two views of the table. It is made of 1-inch pine, the four sides of the box section being firmly screwed together; the cross-rail is also screwed to the battens on the back of the drawing board. The ends of the cross-rail are carefully squared up to provide a good bearing surface for the faces of the uprights, and the ends



Drawing Table with Adjustment to find a Good Bearing for Legs

of the rail are provided with wooden plugs to retain the clamping bolt in position. Iron washers 2 inches in diameter are placed under the nut and under the head of the bolt to distribute the pressure.

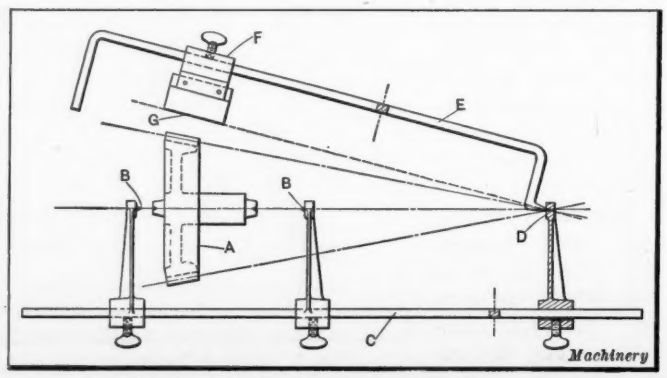
Christchurch, New Zealand. JOHN PEDDIE

BEVEL GEAR PATTERN GAGE

When a patternmaker has to make the patterns for a pair of bevel gears, he turns up the blanks to the required size, using a square and protractor to test the work with from time to time. This method is not particularly satisfactory, as the slight errors in the pattern are likely to result in the production of a very noisy pair of gears.

The illustration presented in this connection shows an improved form of bevel gear pattern gage which I developed to overcome the difficulties resulting from the use of the square and protractor. It will be seen that the gear pattern *A* is supported on centers *B* which are carried on a square rod *C*. A third center *D*, which is in line with the centers *B*, is carried by the same rod. The square rod *E* has a point which is supported by center *D* and this rod carries a support *F* which holds the straightedge *G*.

It will be seen that the centers *B* and *D* and the support *F* are held by wing-nuts so that they may be adjusted to any desired position on their respective bars. In using the gage the bevel gear is set up between centers so that it may be rotated, and the center *D* is located at the required position on bar *C* so that it is at the apex of the cone. Support *F* is then adjusted on bar *E* so that the straightedge engages the



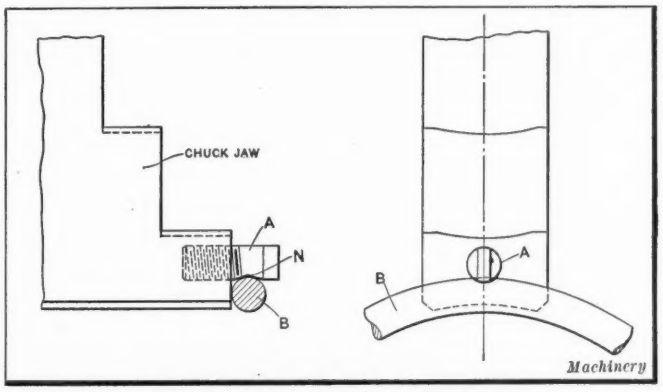
Gage for Use in testing Accuracy of Bevel Gear Patterns

bevel gear as shown, and the straightedge *G* may then be used to test the accuracy of the bevel gear pattern.

Minneapolis, Minn. GLENWOOD MACOMBER

TRUING UP CHUCK JAWS

In the June number of MACHINERY a description was published of a method of truing lathe chuck jaws which would doubtless give very satisfactory results. For some time I have been using a similar method which possesses the advantage of enabling the entire finishing cut to be performed at a single operation. The method is described with the hope that it may prove of value to some readers of MACHINERY. A hole is drilled and tapped in each of the chuck jaws to receive the pins *A* which have a notch cut in them to afford



Improved Method of truing up Chuck Jaws

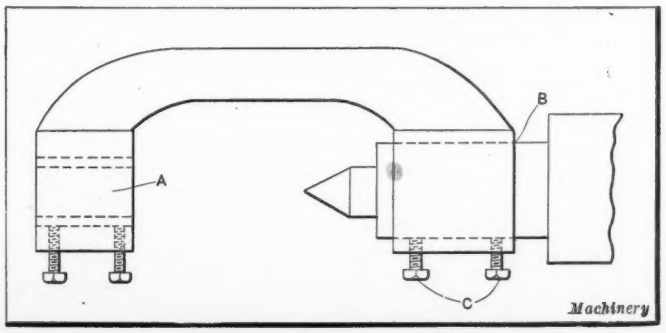
a firm bearing for the centering ring *B*. The pins are flattened in order that they may be turned with a wrench.

In using this method the jaws are tightened against the ring as in the manner described in the June number, but by having the ring engaged by pins instead of by the chuck jaws, it is possible to take the entire refinishing cut at one time, thus enabling the work to be done more rapidly and avoiding the chance of slight errors which may be introduced in starting to take the second cut. It will of course be obvious that hardened chuck jaws will have to be annealed before the holes can be drilled and tapped to receive the pins *A*, but in the case of hardened jaws already provided with holes, it ought to be possible to perform the truing operation with a grinding wheel without the necessity of annealing the jaws to enable them to be trued up with a turning tool.

Chicago, Ill. W. G. DRUMMOND

A TAILSTOCK DRILL-HOLDER

The fixture described in the following was designed for holding straight-shank drills in a lathe without requiring the use of a dog. It consists of a casting with the two holes *A* and *B* bored parallel with each other on the same center line. Hole *B* is made a close fit for the tailstock spindle on which the fixture is held fast by means of two cap-screws *C*, a piece of soft metal being placed under these screws to prevent them from marring the spindle. Hole *A* is bored to a diameter ¼ inch greater than the largest drill which the fixture is required to hold, and bushings of suitable size for the different drills used in the holder are made to fit hole *A*. These bushings should be split and opened slightly so that a good spring clamping action is obtained. The best bushings are made



Drill-holder for Use on the Lathe

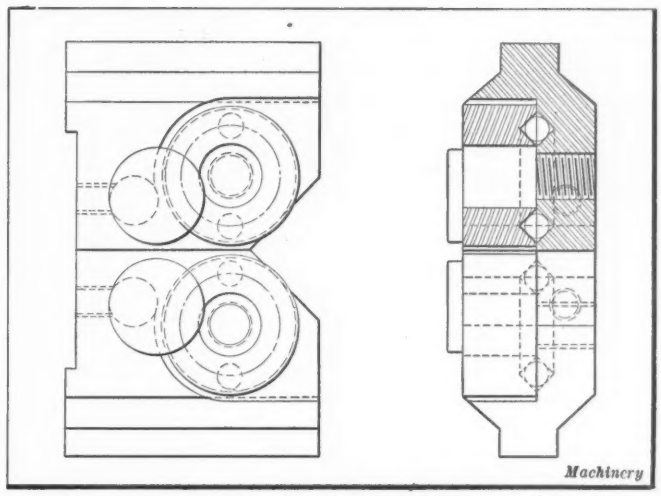


Fig. 1. One of Three Styles of Roller Follow-rests for Use on J. & L. Turret Lathes

from steel and left soft. The rib that connects the two ends of the fixture should be made fairly heavy so that the twisting force exerted by the drill will not throw the two holes out of line with each other. To compensate for variations in the length of different sizes of drills, the end *B* of the fixture is set in different positions on the tailstock spindle according to the size of drill that is to be used. This holder is adapted for use in drilling holes not over 2 inches in depth.

Worcester, Mass. C. H. ANDERSON

ROLLER FOLLOW-RESTS WITH BALL THRUST BEARINGS

To avoid trouble experienced from the V-block follow-rests used on Jones & Lamson turret lathes damaging the turned

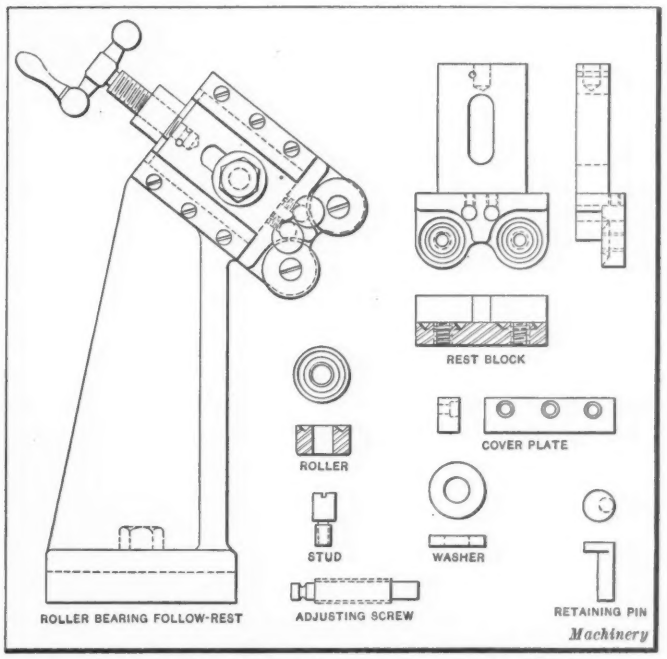


Fig. 2. Roller Follow-rests for Use on Engine Lathes

stock, we designed three styles of roller follow-rests equipped with ball thrust bearings. One of these rests is shown in Fig. 1. The three rests referred to were for turning stock of small and large diameters, and for handling shoulder work. The body of these rests was made similar to that of the V-block follow-rests furnished with the machine, and ball races for thrust bearings were formed concentric with the studs on which the rollers are carried. The rollers are held in place on the studs by eccentric headed pins. The use of these follow-rests has done away with the trouble experienced from the marring of turned surfaces.

Fig. 2 shows a roller follow-rest of similar design which is made for use on engine lathes. It consists of a standard on which there is a planed slide which carries an adjustable block. The two rollers, which are provided with ball thrust-

bearings, are carried by hardened steel shoulder studs mounted in the adjustable block. As in the preceding case, the rollers are held in place by eccentric headed pins. The general construction is the same as that of the follow-rest for the Jones & Lamson turret lathes, and the results obtained in both cases have been equally satisfactory.

Rockford, Ill. E. K. MORGAN

OXY-ACETYLENE WELDING AND CUTTING EQUIPMENT

I have read, with a great deal of interest, Mr. Miller's articles in the October number of MACHINERY. His descriptions and photographs of actual welding work and his methods of preparation, overcoming contraction strains, etc., undoubtedly will be a great help to users of the oxy-acetylene process. The experiences of practical men, clearly expressed, should be of decided benefit, and Mr. Miller's long experience in the repair business peculiarly qualifies him as an expert in this line; users of the system will profit by his knowledge.

In justice to the process of oxy-acetylene welding and cutting and to many manufacturers of high-class apparatus, however, it seems to me that that portion of Mr. Miller's articles entitled "Oxy-Acetylene Welding and Cutting Equipment" needs further discussion. Mr. Miller describes on page 86 the methods pursued to overcome the tendency of acetylene to burn backward, and states that unless the tube used is a very small one, this danger is great. He may have had such an experience, but I can find no authority for any such statement; in hundreds of experiments I have never been able to make acetylene burn against the flow and I know of no one who has been able to do this. If this were true, every acetylene house lighting equipment would be a menace, for in this case the flow of gas is at a very low speed and through a fairly large pipe. Acetylene (or any other combustible gas) will not burn unmixed with air or oxygen, and if Mr. Miller will try the experiment for himself I think he will agree. If, however, acetylene is heated to a sufficiently high degree (authorities place this point at about 800 degrees F.) it will explode without air mixture; but this condition cannot very well be obtained in a welding torch.

The danger which Mr. Miller describes, then, is not in the acetylene but in the mixed gases, and any well constructed torch must be provided with such devices as are thought to prevent the propagation of the flame beyond the torch. Whether this can be accomplished by means of small holes or by packing in the handle is a question still open to considerable discussion. It has by no means been proved that either will prevent it under some conditions well known to manufacturers of welding apparatus. The point I wish to bring out clearly is that acetylene properly handled is not a dangerous gas to use. It has been misunderstood more than any other gas, and wrong impressions have been created regarding it. It should be clearly understood that with the proper air mixtures it will burn against the flow, but without such mixtures it cannot do so.

Further on, Mr. Miller states that the welding torches in use may be divided into two classes: low-pressure and medium-pressure; he defines the low-pressure torch as one using acetylene under a few ounces pressure, and the medium-pressure as one using acetylene under a pressure as great as six pounds. In justice to the conscientious manufacturers of the equal-pressure type, a descriptive article of welding apparatus is not complete without an explanation of this type of torch. In this country, the divisions should properly include three classes: Low-pressure (or injector) torches, where the acetylene is under a very low pressure and the oxygen under a comparatively high pressure; medium-pressure torches, where the acetylene may be used under a pressure of somewhat less than fifteen pounds and the oxygen under a pressure averaging about twice the acetylene pressure; and equal-pressure torches, where both gases move at about the same speed. The "Oxweld," "Delcampe" and "Messer" are examples of the first class; Davis-Bournonville, "Vulcan," Henderson-Willis "Searchlight," Milburn, "Economy," "Meco" and Metals Welding of the second; and "Prestolite," Waterhouse, Dyer, "Imperial," and Tolman of the third. Which particular type is the best one to use cannot be said in a fair article; but the very fact that the equal-pressure torch lowers the velocity of the oxygen—and this has been sought for in all types of torches—demands its consideration in any discussion of welding apparatus. The particular apparatus which Mr. Miller describes at length is unquestionably a high-class one and the manufacturers of it have the admiration of everyone connected with the industry, but it is by no means the only good apparatus; nor the only economical one. It is simply in a spirit of fair play to the manufacturers of other types that I call attention to this oversight.

On page 92 is this statement: "Acetylene has the property of having more heat units per cubic foot than any other gas. . . . Consequently, if it were completely burned, it would produce the maximum temperature possible in a gas flame." "Blaugas," "Wolf Gas," "Gasol," "Thermalene," and two or three others, have more heat units than acetylene and any one of these gases will produce more heat than acetylene. None of them, however, will give the flame temperature of oxygen and acetylene, for reasons which have previously been explained in MACHINERY. The danger of a statement of this kind lies in the fact that it may be quoted (as similar statements have been) by manufacturers of gases having more heat units than acetylene, and the natural inference of the reader would be that if acetylene with 1600 heat units gives a flame of 6300, then this other gas with 2200 heat units undoubtedly would give 8000 or more; when as a matter of fact the combination of oxygen and acetylene gives a much hotter flame than any other combination.

"It is perfectly safe to compress acetylene into such tanks" on page 92 is a misleading statement. Somebody is going to take this literally and proceed to pump acetylene into the well-known safety storage cylinder (as embryonic gas manufacturers have attempted to do in the past, usually with disastrous results) unless it is shown that the act of compressing acetylene is attended with considerable danger. Any one of the three large manufacturers of dissolved acetylene can probably testify to the truthfulness of this statement, and they have learned it at the cost of wrecked plants. After the gas is in a properly constructed tank, it may be considered safe, but certainly it is quite unsafe to compress it.

The development of the oxy-acetylene process of welding and cutting is largely dependent upon the purity, convenience and price of the oxygen; and the Linde Air Products Co., as the largest producer in this country, is certainly a big factor, but in my opinion the oxy-acetylene industry should also give thanks to the Superior Oxygen Co., the Burdett Mfg. Co., the International Oxygen Co. and to numberless smaller companies who have done much to widen its scope.

On page 88, Mr. Miller states that "nitrogen . . . even when small, has an adverse effect on a weld," and later on that "hydrogen, which does not injure the weld." On page 90 he corrects the first statement by saying, "is nitrogen, which is chemically inert, so that it has little detrimental effect upon the steel or other metal which is being welded." Undoubtedly nitrogen is inert and practically the only effect it has is to somewhat reduce the flame temperature, and it is present in liquid air oxygen to such a slight extent that it could not be noticed in a welding flame by even the most expert operator. If hydrogen were present to any large extent in electrolytic oxygen, it would manifest itself in the character of the welding flame and the water vapor created by the combustion of oxygen, and this gas would be a serious detriment to a successful steel weld. Fortunately neither foreign element, nitrogen nor hydrogen, is present in oxygen manufactured by the two systems in sufficient quantities to materially affect the flame temperature, on the one hand, or the character of the weld on the other.

Mr. Miller's articles are going to be too valuable to the oxy-acetylene industry to allow misunderstandings or misstatements to become known as facts, and without a spirit of criticism, but wholly with the feeling of fair play toward each contributor to the success of welding and cutting apparatus, this article is written.

New York City. M. KEITH DUNHAM

NEW MACHINERY AND TOOLS

THE COMPLETE MONTHLY RECORD OF NEW DESIGNS AND IMPROVEMENTS IN AMERICAN METAL-WORKING MACHINERY AND TOOLS

LEES-BRADNER SHELL THREAD MILLING MACHINE

This machine employs a special form of multiple cutter which is similar to a hob used for generating gear teeth. The cutter is the length of the thread which it is required to mill, and as a result it is merely necessary to rotate the work through one complete revolution plus a slight over-travel. The use of this principle makes it possible to mill threads on this machine with a very satisfactory rate of production. An idea of just what the productive capacity amounts to may be gathered from the figures presented in the article, which give the rates of output for different thread milling operations on shells and fuse parts.

For the performing of internal and external threading operations, the Lees-Bradner Co., Cleveland, Ohio, has developed a milling machine, front and end views of which are shown in the accompanying illustrations. A positive opening and closing collet is provided for holding the work, this collet being located on the inside of the work-spindle and controlled by a hand-wheel at the rear end of the spindle. The threading is done by a multiple type of cutter which makes it necessary for the work to revolve only a little more than one revolution in order to finish the cut. The machines are built in four different sizes which have capacities for holding work from 3¼ to 9½ inches in diameter.

These threading machines are particularly adapted for use in machining shrapnel and high-explosive shells, and some of the rates of production obtained should prove of interest. In threading 18-pound high-explosive shells, the rate of production obtained is forty per hour. In threading nose pieces for 4½-inch high-explosive shells, 400 pieces were threaded in 9¾ hours. In the two cases just referred to the threaded hole is 2 inches in diameter by 1.2 inch in length and has 14 Whitworth threads per inch. In threading standard bronze fuse pieces on which the threaded portion is 1.2 inch in diameter, 1100 pieces were produced in a ten-hour day.

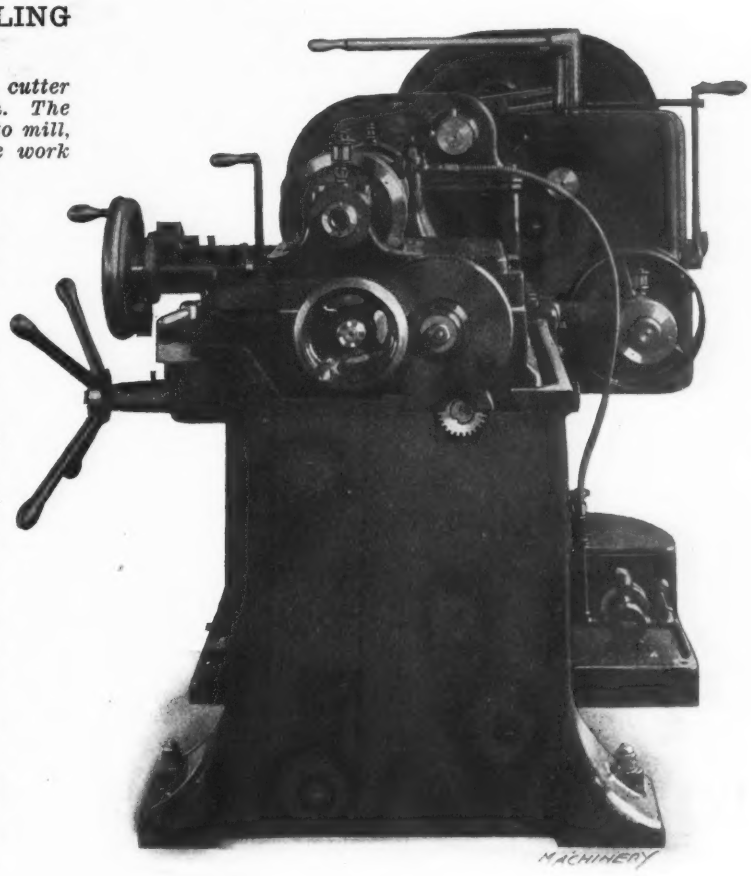


Fig. 2. End View of Lees-Bradner Thread Milling Machine shown in Fig. 1

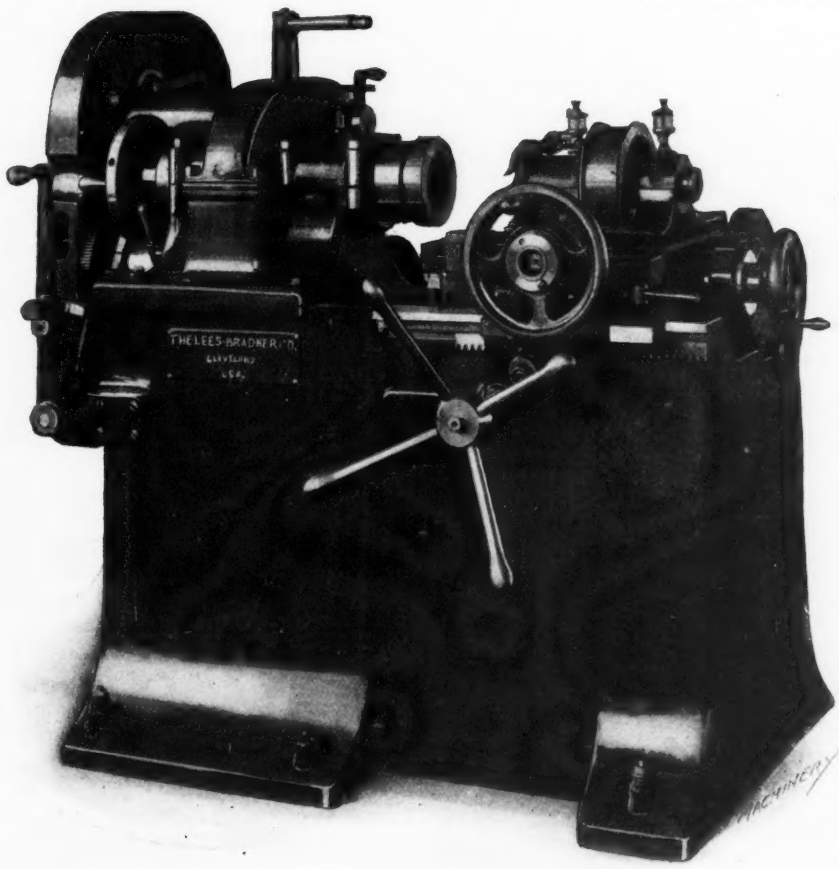


Fig. 1. Lees-Bradner Thread Milling Machine for Internal and External Threading Operations

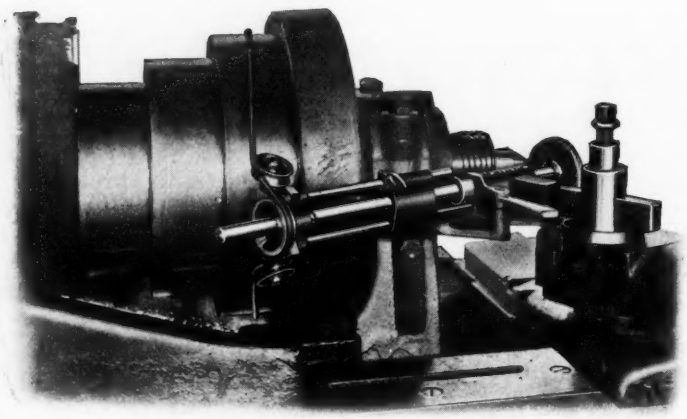
On machines which have a chucking capacity for work up to 6 inches in diameter, the cutter-spindle is driven direct; and on machines with a capacity for work ranging from 8 to 9½ inches in diameter, a back-geared drive is employed, which provides sufficient power to enable the machine to mill threads 3½ inches in length in a single cut, *i. e.*, at one revolution of the work with a small over-travel. The machines for work from 3 to 6 inches in diameter are usually belt-driven, while the machines for work from 8 to 9½ inches in diameter may be either driven by a belt or by individual electric motor. When the motor drive is employed, it allows a crane to be used over the machine.

LEADER CENTER GRINDER

The center grinder which forms the subject of the following description was designed by C. M. Stretcher and is made by the Leader Mfg. Co., Springfield, Ohio. The most important feature of the tool is that it is driven from the lathe cone pulley by means of a round belt, so that no special provision need

be made for driving. Another noteworthy feature is that it can be used on any lathe regardless of whether the machine is provided with a compound rest or not.

It will be evident from the illustration that the tool is provided with a shank to fit in the toolpost, and the method by which it is driven from the cone pulley on the machine is also clearly shown. It will be seen that a short lever is provided which enables the spindle that carries the grinding wheel to be traversed back and forth for the purpose of feeding the wheel across the center to grind it accurately to shape. With one of these tools in a shop, there is no excuse for not having the lathe centers kept perfectly accurate. The weight of the tool is 6½ pounds and the simplicity of the design makes it an easy matter for the tool to be set up and used by any workman of average intelligence.



Stretcher Center Grinder made by the Leader Mfg. Co.

ILLINOIS DIE FILING MACHINE

In designing this machine, provision has been made for tilting the entire mechanism over in such a way that the operator may obtain a clear view of his work when using the off side of the file. It will be seen that both the motor and the driving mechanism are completely enclosed, providing adequate protection against filings and dust. A system of forced lubrication is employed, which insures smoothness of operation, durability of working parts, and the elimination of noise and vibration.

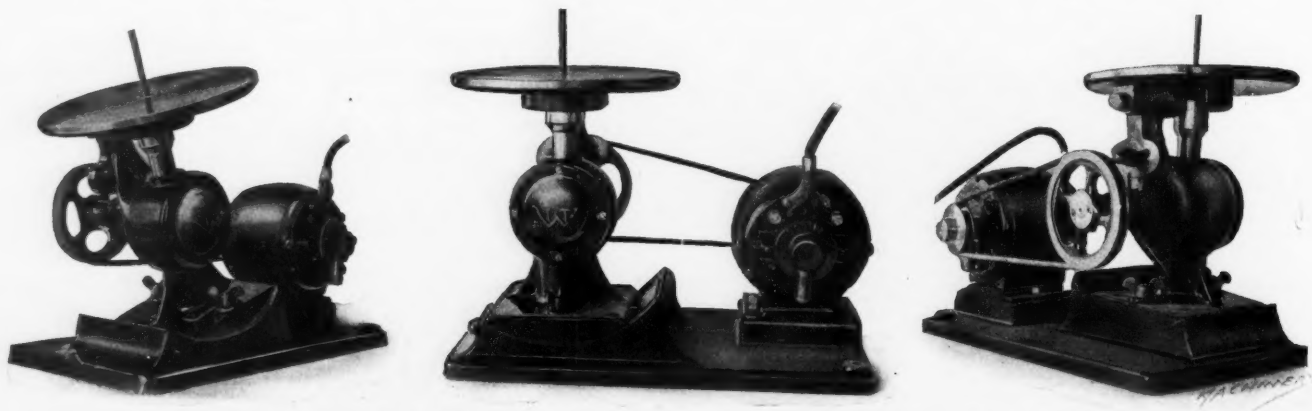
The Illinois Tool Works, 154-166 E. Erie St., Chicago, Ill., does an extensive business in the making of dies, and for use on this work the die filing machine which is shown in the accompanying illustrations was developed. The original idea was to produce a machine for use in the shops of the Illinois Tool Works, but the results obtained have been so satisfactory that it has been decided to build it for the market. The most noteworthy features of the design are the arrangement for tilting the entire mechanism of the machine so that the operator may use the off side of the file and still obtain a clear view of his work without leaning over the spindle or getting in his own light, the provision of a system of forced lubrication for the driving mechanism, and the protection of all working parts from filings and dust. These features will be described in detail in subsequent paragraphs.

It will be seen that the machine is provided with individual electric motor drive, the motor used for this purpose being a 1/10 horsepower unit built by the Bodine Electric Co., Chicago, Ill. The motor may be supplied for use in connection with a circuit of any current and voltage; it runs at 1600 revolutions per minute and the filing machine makes 720 strokes per minute, the length of stroke being 1 inch. The table of the machine is mounted on a pivoted support which provides for setting it at any required angle with the spindle to obtain the desired clearance in the die which is being filed; and a graduated scale is secured to the frame of the machine to provide for setting the table at the required angle with the spindle. It has been mentioned that the machine is mounted on a pivoted support so that the entire mechanism may be swiveled to enable the operator to have a clear view of his work. In filing a die, it is frequently most convenient to have the file working on the side of the hole farthest away from the operator and when working in this way the machine is tilted toward the operator so that the file does not obstruct his view of the outline to be followed.

It will be noticed that the entire driving mechanism is enclosed in a dust-proof case. This is very important in the case of a filing machine as there would otherwise be a tendency for filings to find their way into the mechanism and cause an undue amount of wear. This form of enclosed construction also makes it possible to employ the system of forced lubrication referred to in the opening paragraph. In setting up the machine it is merely necessary for the operator to fill the case with oil to the level indicated in Fig. 4, after which no attention is required to see that proper lubrication is obtained. The mechanism which provides forced lubrication is clearly shown in this illustration and the method of operation is as follows:

Frame *A* which encloses the mechanism is filled with oil to the highest level provided for by barrier *B*. On its upward stroke pitman *C*, which drives the spindle, creates a partial vacuum in channels *D* and *E* and well *F*, with the result that oil flows in from the supply carried in the frame of the machine. On the downward stroke pitman *C* descends and covers opening *G*, thus preventing the escape of oil through passage *E*. As a result, the only path of escape for the oil as pressure is developed by the continued downward movement of the pitman is through passage *D*, which leads to oil tube *H* that throws oil over the entire surface of pitman *C*, cross-head *I* and crank disk *J*. In this way, the oil finds its way into all crevices around the slide *K*, and the crank-pin is thoroughly lubricated by oil creeping into the slide space of the cross-head *I*.

In addition, the edge of crank disk *J* dips into the oil carried in the reservoir in the frame of the machine, and in revolving carries up a supply of oil on its rim, which flows into notch *L* and thence through channel *M* to provide for lubrication of the crankshaft bearing. The oil thrown onto pitman *C* is carried to the upper bushing *N* on the upward stroke; and the lower bushing *O* is well lubricated by oil which is carried into the bearing space on the downward stroke of the pitman. The oil carried in the well *F* serves the further purpose of



Figs. 1 to 3. Three Views of Illinois Die Filing Machine showing Different Settings that may be obtained

taking up the impact of the pitman and eliminating vibration, so that the operation of the machine is extremely smooth. As a result, the work done on the machine is accurate and the finish produced is extremely satisfactory.

The machine uses standard files of the form made for use on die filing machines, and the chuck is designed to give a three-point contact on the round shank of the file. A supply of ten assorted files is furnished as part of the equipment. The machine illustrated in connection with this description is arranged for electric motor drive, but if so desired this filing machine can also be provided for belt drive from a countershaft.

The principal dimensions are as follows: diameter of table, 9 inches; height of machine, 12 inches; bench space occupied, 16 by 10 inches; and weight of machine, 54 pounds.

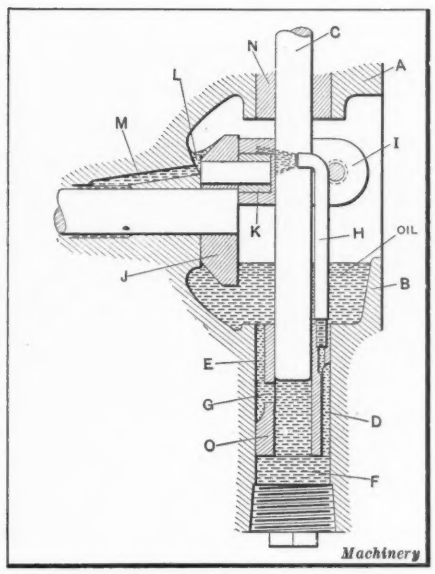
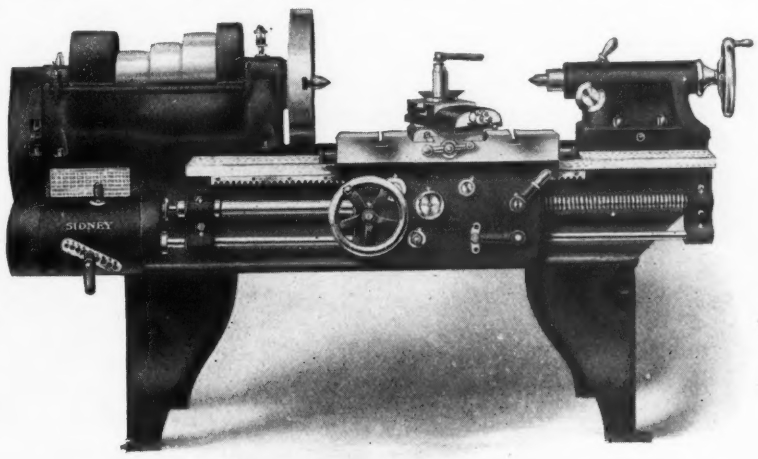


Fig. 4. Cross-sectional View through Driving Mechanism, showing Forced Lubricating System

SIDNEY ENGINE LATHE

The general features of design of the 17- and 19-inch double back-geared engine lathes which have recently been placed on the market by the Sidney Tool Co., Sidney, Ohio, will be apparent from the illustration presented in connection with the following description. Among the more important structural features of the machine, the following are worthy of mention. The bed is made with heavy double-wall girths placed at intervals of two feet, which provide an exceptionally rigid construction. There is a large bearing at the front of the bed and a standard sized bearing at the back; the bearings are carefully chilled to produce a hard close-grained metal. The carriage V-bearing is 2½ inches in width and the bridge is liberally proportioned. The carriage is drilled to receive a taper attachment so that the machine may be easily equipped for taper turning after it has been installed. The compound rest is rigidly designed and the swivel is made completely circular and graduated in degrees. Full length tapered gibs with end screw adjustment are provided on both the cross- and compound-rest slides.

The headstock is of the closed type and is offset one inch, making it better adapted for high-duty work. The headstock spindle is made of 50 point carbon steel and runs in phosphor-bronze boxes. The tailstock spindle is clamped in position by means of a double binder which is constructed in such a way as to clamp the spindle in any position without affecting its alignment. The apron is a one-piece casting in which all bearings are integral with the apron. All gears are provided with bearings at both ends and the feed-rod is also supported at both ends. The lead-screw is made of 40 point carbon steel and is 1 7/16 inch in diameter. All gears in the quick-change gear mechanism are made of high-carbon steel, and the cone gears employed in the quick-change mechanism are cut with an improved type of 22½-degree cutters, which form a pointed tooth that is slightly rounded at the top. This permits instantaneous engagement of the gears without interference. The quick-change mechanism forms a complete unit and is mounted on the machine by means of a tongue and groove joint which insures accurate alignment. It provides changes for a wide range of feeds and thread cutting operations which are listed on a direct-reading index-plate located above the tumbler lever.



Double Back-geared Engine Lathe made in 17- and 19-inch Sizes by the Sidney Tool Co.

As previously mentioned, the machines are made in nominal sizes of 17 and 19 inches, and both sizes are built with 6-, 8-, 10-, and 12-foot beds. The principal dimensions of the 17-inch lathe are as follows: swing over ways, 19 inches; swing over carriage, 11¼ inches; travel of tail-spindle, 8 inches; size of hole through head-spindle, 1 9/16 inch; width of driving belt, 3½ inches; ratio of back-gears, 3.55 to 1 and 10 to 1; number of changes of feed, 32; range of threads, 3 to 46 per inch; available spindle speeds, 13 to 360 R. P. M.; and weight of machine, approximately 3100 pounds.

The principal dimensions of the 19-inch machine are: swing over ways, 21 inches; swing over carriage, 13¼ inches; travel of tail-spindle, 8 inches; diameter of hole through head-spindle, 1 9/16 inch; width of driving belt, 4 inches; ratio of back-gears, 3.25 to 1 and 10 to 1; number of quick-change feeds, 32; range of threads, 3 to 46 per inch; available spindle speeds, 13 to 360 R. P. M.; and weight of machine, approximately 3300 pounds.

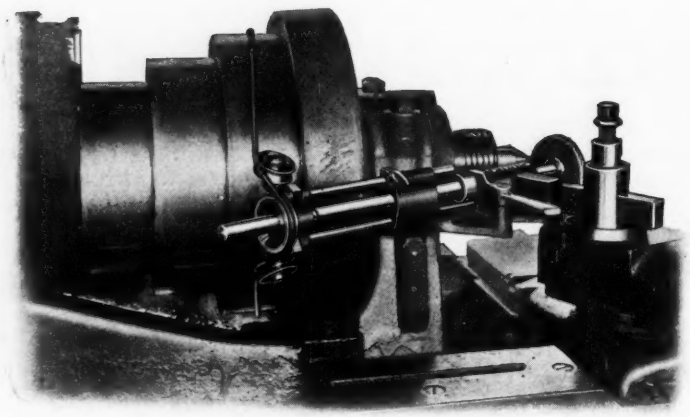
NEWTON RAIL ENDING MACHINE

The rail ending machine shown in the accompanying illustration has been developed by the Newton Machine Tool Works, Inc., Philadelphia, Pa., to meet the requirements of a machine for operating on high-carbon, high-manganese, open-hearth steel rails of the kind which are now in general use. The general design of the machine follows that of preceding types of rail ending machines built by this company, but has been modified to meet the severe service incident to working on rails rolled from the material referred to. The driving motor is mounted at the top of the machine and drives through a 10-inch belt which transmits the power to the spindle through a phosphor-bronze worm-wheel and hardened steel worm of steep lead. The worm-wheel is double keyed to the spindle, and the statement that the spindle is one-half the diameter of the cutter-head will give a better idea of the way in which these parts are proportioned than by quoting actual dimensions. The bearings are capped and bronze-bushed, so that compensation for wear is provided.

The feed is provided by a stationary screw and revolving nut, and the thrust is taken by enclosed ball bearings. The spindle has a movement of 2¾ inches and hand adjustment of the spindle is provided; there are four changes of feed of 1/64, 1/32, 3/64 and 1/16 inch per revolution, the speed of the cutter-head covering a range of from 5 to 15 revolutions per minute. The spindle is provided with an adjustable automatic stop and safety limits so that the spindle cannot jam at either end; and it is furnished with a power quick-return motion. All gears are fully enclosed, and the principal driving and feed gears run in oil. The base of the machine is surrounded by a pan, and the machine is fitted with a pump and distributing system for supplying cutting compound to the tools. Cored openings are provided in the base to facilitate the removal of chips; and lift-

be made for driving. Another noteworthy feature is that it can be used on any lathe regardless of whether the machine is provided with a compound rest or not.

It will be evident from the illustration that the tool is provided with a shank to fit in the toolpost, and the method by which it is driven from the cone pulley on the machine is also clearly shown. It will be seen that a short lever is provided which enables the spindle that carries the grinding wheel to be traversed back and forth for the purpose of feeding the wheel across the center to grind it accurately to shape. With one of these tools in a shop, there is no excuse for not having the lathe centers kept perfectly accurate. The weight of the tool is 6½ pounds and the simplicity of the design makes it an easy matter for the tool to be set up and used by any workman of average intelligence.



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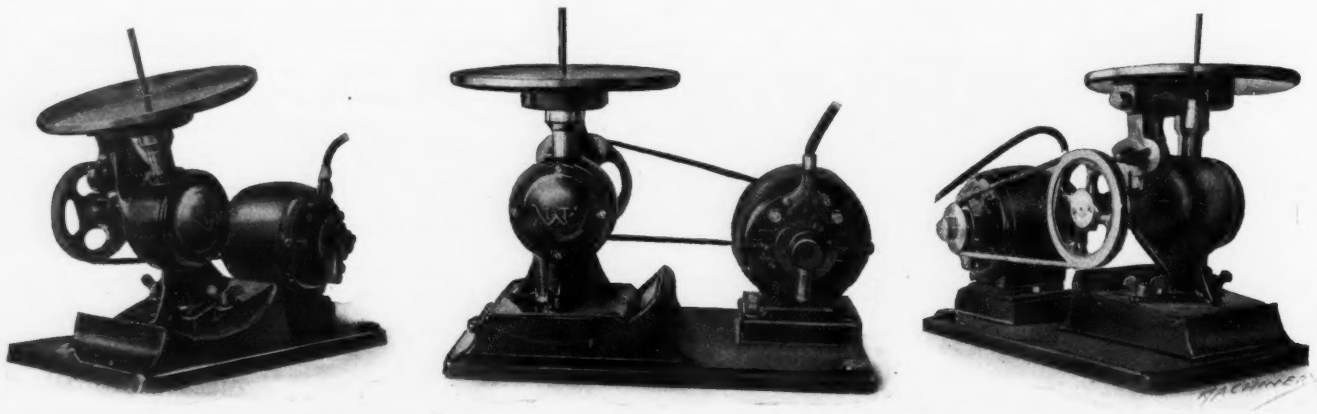

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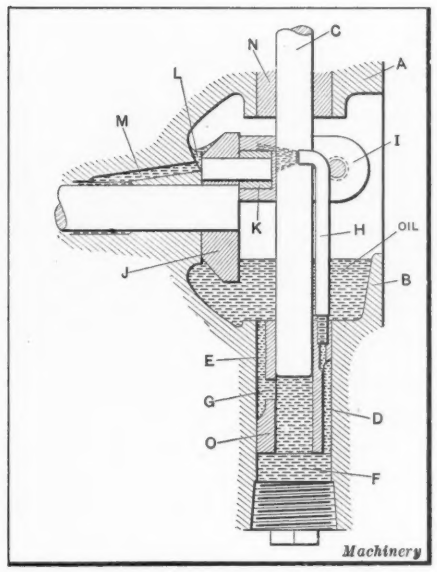

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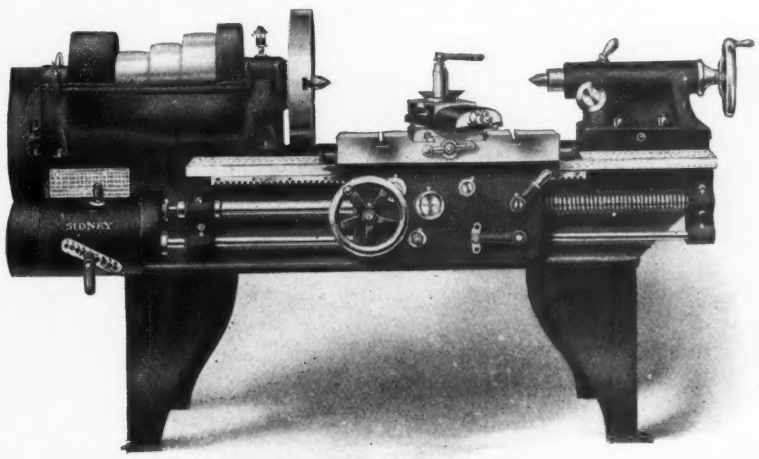


Double Back-geared Engine Lathe made in 17- and 19-inch Sizes by the Sidney Tool Co.

As previously mentioned, the machines are made in nominal sizes of 17 and 19 inches, and both sizes are built with 6-, 8-, 10-, and 12-foot beds. The principal dimensions of the 17-inch lathe are as follows: swing over ways, 19 inches; swing over carriage, 11¼ inches; travel of tail-spindle, 8 inches; size of hole through head-spindle, 1 9/16 inch; width of driving belt, 3½ inches; ratio of back-gears, 3.55 to 1 and 10 to 1; number of changes of feed, 32; range of threads, 3 to 46 per inch; available spindle speeds, 13 to 360 R. P. M.; and weight of machine, approximately 3100 pounds.

The principal dimensions of the 19-inch machine are: swing over ways, 21 inches; swing over carriage, 13¼ inches; travel of tail-spindle, 8 inches; diameter of hole through head-spindle, 1 9/16 inch; width of driving belt, 4 inches; ratio of back-gears, 3.25 to 1 and 10 to 1; number of quick-change feeds, 32; range of threads, 3 to 46 per inch; available spindle speeds, 13 to 360 R. P. M.; and weight of machine, approximately 3300 pounds.

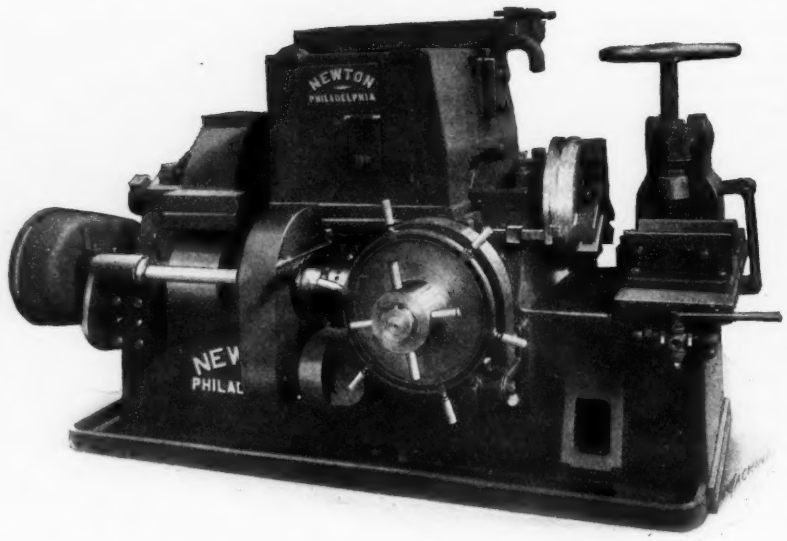
NEWTON RAIL ENDING MACHINE

The rail ending machine shown in the accompanying illustration has been developed by the Newton Machine Tool Works, Inc., Philadelphia, Pa., to meet the requirements of a machine for operating on high-carbon, high-manganese, open-hearth steel rails of the kind which are now in general use. The general design of the machine follows that of preceding types of rail ending machines built by this company, but has been modified to meet the severe service incident to working on rails rolled from the material referred to. The driving motor is mounted at the top of the machine and drives through a 10-inch belt which transmits the power to the spindle through a phosphor-bronze worm-wheel and hardened steel worm of steep lead. The worm-wheel is double keyed to the spindle, and the statement that the spindle is one-half the diameter of the cutter-head will give a better idea of the way in which these parts are proportioned than by quoting actual dimensions. The bearings are capped and bronze-bushed, so that compensation for wear is provided.

The feed is provided by a stationary screw and revolving nut, and the thrust is taken by enclosed ball bearings. The spindle has a movement of 2¾ inches and hand adjustment of the spindle is provided; there are four changes of feed of 1/64, 1/32, 3/64 and 1/16 inch per revolution, the speed of the cutter-head covering a range of from 5 to 15 revolutions per minute. The spindle is provided with an adjustable automatic stop and safety limits so that the spindle cannot jam at either end; and it is furnished with a power quick-return motion. All gears are fully enclosed, and the principal driving and feed gears run in oil. The base of the machine is surrounded by a pan, and the machine is fitted with a pump and distributing system for supplying cutting compound to the tools. Cored openings are provided in the base to facilitate the removal of chips; and lift-

ing hooks are furnished on the machine to enable it to be readily transferred from one fixed position to another to take care of handling the different lengths of rails produced in the mill. The cutter-head is of the three-tool type and uses either solid cutters or tool-holders.

The rail to be finished on the machine is held by a chuck which is fitted with hardened serrated clamping plates, and the mouth of the chuck is beveled in all directions to facilitate introducing the rail. The clamping mechanism is of the patented clearance, air-operated type developed by the Newton Machine Tool Works, and provides a clamping pressure of 32 tons. The clamp is operated by the valve shown at the front of the machine, and the adjusting screw on the air clamp is provided with a handwheel to take care of various sections of rails produced in the mill. These rail ending machines are used in conjunction with machines for drilling the splice bar holes, and in designing them the aim has been to produce an equipment with a productive capacity on T-head rails which exceeds the capacity of the drilling machines.



Rail Ending Machine built by the Newton Machine Tool Works

DEVELOPMENT IN STEAM POWER AIR COMPRESSORS

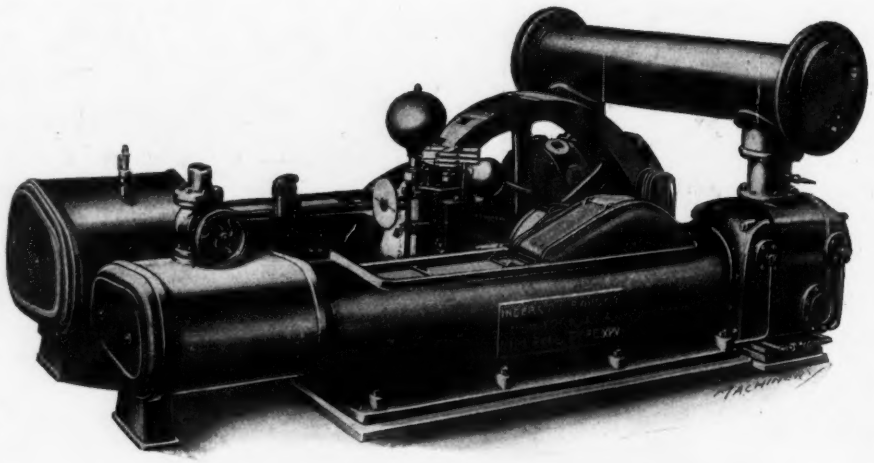
Present-day steam engineering practice is marked by the wide use of high-pressure and superheated steam. This condition has made the use of the slide valve gear, even of the adjustable cut-off type, obsolete practice on steam-driven air compressors. The slide steam valve in various forms has been generally used on air compressing units below the sizes (about 25-inch stroke) where the use of the Corliss valve gear becomes commercially practicable. At high temperatures the slide valve is very unsatisfactory due to its tendency to warp, with consequent leakage; and under these conditions there is also an increasing difficulty with lubrication, which results in excessive wear and a greater force required to drive the valve. To provide a steam-driven air compressor which will operate satisfactorily with high pressure and superheat, as well as at moderate pressures, the Ingersoll-Rand Co., 11 Broadway, New York City, has developed a balanced piston steam valve gear. This has been incorporated in the design of the standard "Imperial" duplex air compressors.

The use of a balanced valve makes it possible to control the machine in the only really economical manner, *i. e.*, by automatically varying the point of cut-off in the steam cylinders. This method of regulation maintains constant speed for changing steam pressures and at the same time varies the speed of operation according to the demand for air. Steam is always admitted to the steam cylinder at full boiler pressure and without the wire drawing of a governor of the throttling type, which means, in short, that the machine automatically operates at its highest efficiency. It is pointed out that the higher the steam pressure the greater the relative increase in efficiency. With the hand adjusted cut-off valves, which are usually set at ⅝ or ¾ of the stroke, the steam economy is admittedly poor; while with an automatic cut-off regulation, the saving in actual steam consumption is the point most emphasized by the manufacturer.

This piston valve is a perfectly balanced valve of the telescopic type; and the cut-off valves are right- and left-hand threaded to a cut-off valve stem. Steam admission is through the center of the valve, the steam then passing through the valve ports to the cylinder, from which it is exhausted by the ends of the valve. It is to be noted that this construction exposes the valve chest covers and steam packings to exhaust pressure only, thus proportionately reducing the liability of leakage. The design and even distribution of metal in the "Imperial" piston valve are claimed to preclude any possibility of warping and to result in a valve which is so balanced that friction is minimized and lubrication facilitated.

The steam ports are large and unusually direct, and a special effort has been made by the manufacturer to reduce the condensation surfaces in the cylinders. Exceptionally complete insulation, the separation of live and exhaust steam passages, and the fact that the steam chest partially encircles the cylinder contribute to the steam economy. The cylinder and receiver lagging are covered with a sheet iron casing and the cylinder heads with cast covers.

The steam receiver is a direct connection between the high- and low-pressure steam chests. The low-pressure chest is proportioned to furnish additional capacity, and is so located that the heat ordinarily lost by radiation is used in heating the cylinder and valve. A special expansion joint prevents any possibility of the cylinder alignment being destroyed. The governor is a speed and pressure regulator which varies the cut-off by automatically rotating the cut-off valve stem and changing the relative position of the cut-off valves. It is essentially a chain driven rotary oil pump which acts against a weighted plunger. The variation in oil pressure due to the changing speed of the compressor, or the varying air pressure through the movement of the plunger, changes the cut-off point in the steam cylinders.



Ingersoll-Rand "Imperial" Type XPV Air Compressor with Balanced Piston Steam Valve Gear for Use with High-pressure Superheated Steam

This governor is claimed to be entirely automatic in operation and capable of maintaining exceptionally reliable as well as close regulation. Lubrication of both air and steam cylinders and valves is provided for by forced-feed oilers. The other features of this compressor, which is called the

"Imperial" Type XPV, are those of the "Imperials" now in service; wholly enclosed main frames containing the reciprocating parts, automatic lubrication by the bath system and the standard completely water jacketed air compressing cylinders. This "Imperial" Type "XPV" compressor is built in capacities from 608 to 3620 cubic feet per minute and for discharge air pressures from 10 to 110 pounds per square inch.

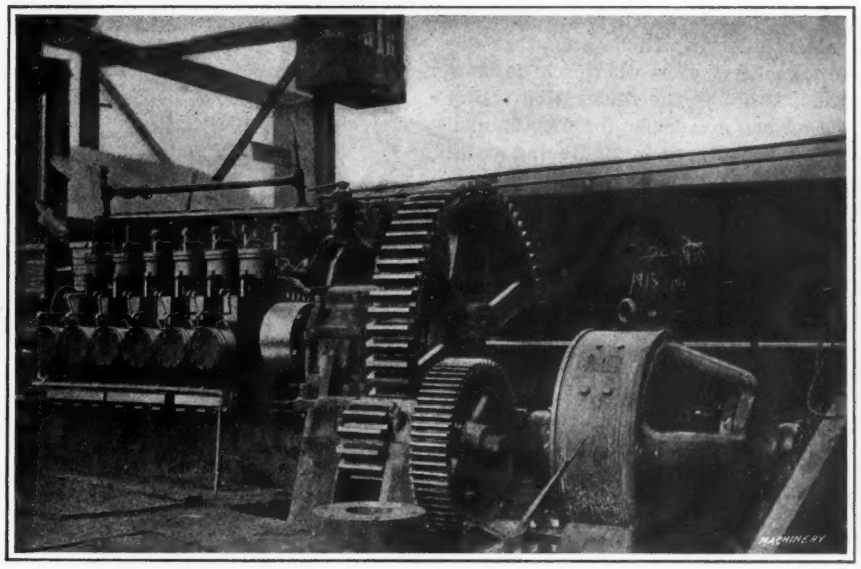


Fig. 1. Southwark Cutting-off Machine cutting Six Blanks at a Time from a Bar 5½ inches in Diameter

SOUTHWARK CUTTING-OFF MACHINES

The McMeans-Bosler cutting-off machines which are illustrated and described herewith are a recent product of the Southwark Foundry & Machine Co., 430 Washington Ave., Philadelphia, Pa. The cutting is done by three air-operated cutting-off tools which are mounted in a common head, all three tools cutting in the same kerf. The tools are forced into the work by air pressure which is claimed to be an advantageous method in that the pressure on the tool remains constant and enables the depth of the cut to be automatically regulated according to the hardness of the metal. Furthermore, if the bar is out of round the tool backs away slightly at the high spots, thus maintaining a constant cutting depth. As a result, the machine may be operated at the maximum depth of cut which the tools will stand without danger of damage in case the tools encounter an exceptionally hard or high spot in the work. The machines are made in two types and in several sizes. The first type, which is shown in Figs. 1 and 2, is a multiple-head machine equipped with six three-tool air-operated heads mounted on a cast-iron or structural steel bed. There is a heavy driven headstock at one end of the bed, which carries the chuck; and the cut-off heads also serve as steady-rests. There is no tailstock on the machine, the bar being fed in from one end.

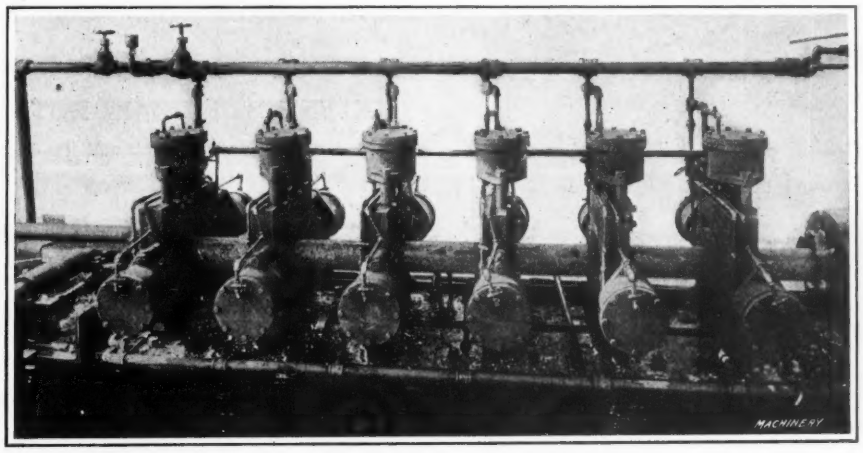


Fig. 2. Machine shown in Fig. 1 set up for cutting off Blanks 19¾ inches in Length

The second type referred to is a single-head machine which consists of a cutter-head with three air-operated cutting-off tools which operate in the same kerf, the design of the head being similar to that of the heads on the multiple machine. The single head is moved along the bed of the machine by means of an air cylinder. At the end of the bed there is a heavy headstock which is either belt-driven or geared to an individual motor.

These machines do not cut the bar entirely through but leave a neck at the center, of somewhat less than one-third the diameter of the original bar, as required by shell specifications. The blanks are separated by breaking the necks of metal left between, and the fractured ends disclose any pipes or flaws more plainly than if they were sawed clear through. In general, the time in seconds required to cut through a bar is three or four times the square of the diameter of the bar in inches. In many cases the time in seconds required to cut through a bar has been only twice the square of the diameter in inches, but this rate of cutting could not be maintained.

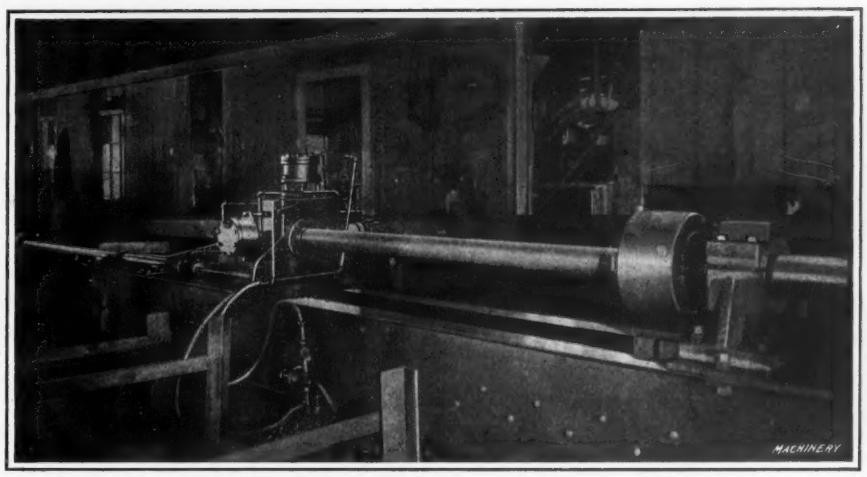


Fig. 3. Southwark Cutting-off Machine of the Single-head Type

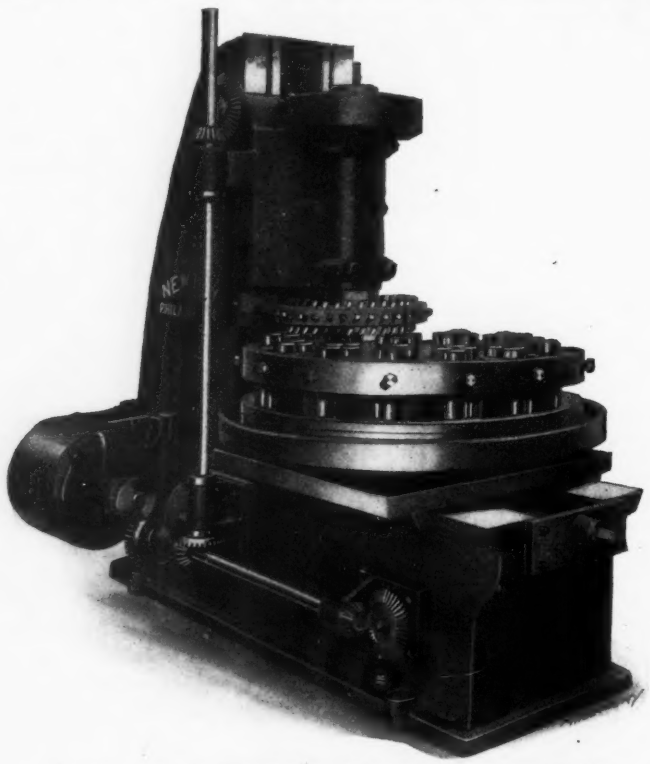
NEWTON VERTICAL MILLING MACHINE

The vertical milling machine illustrated and described herewith has recently been added to the line of the Newton Machine Tool Works, Inc., Philadelphia, Pa., and is intended for use in milling off the solid end of shrapnel and high-explosive shell blanks. The design of the machine is not a new development, but the adaptation of the special chuck or fixture for holding the work provides for continuous operation in milling shell blanks. The machine is equipped with a cutter 10 inches in diameter, and the finished work can be removed and fresh blanks substituted in the fixture without stopping the feed.

After the forgings have been rough-

turned, they are set up in the fixture which has a capacity for holding sixty pieces at a time. It will be seen that the fixture is sub-divided into pockets, each of which is now arranged to hold five blanks, although the illustration shows a fixture in which each pocket has a capacity for four blanks. All of the blanks in the pocket are secured by tightening a single screw.

The principal dimensions of the machine are as follows: diameter of spindle, 5 inches; outside diameter of table, 54 inches; in-and-out adjustment of table, 10 inches; diameter of driving worm-wheel of spindle, approximately 18¾ inches; and length of spindle bearing, 24 inches. The spindle bearing is capped and bronze-bushed, and the work table has three changes of circular feed with hand adjustment for both the circular and in-and-out movement.



Newton Vertical Milling Machine facing off Ends of Shell Blanks

CONSOLIDATED SHELL BAKING OVEN

For the purpose of reducing the time required to bake the copal varnish applied to the inside of high-explosive shells, the Consolidated Car Heating Co., 419-423 N. Pearl St., Albany, N. Y., has recently developed an electrically heated oven of compact design which is rigidly constructed to stand up under severe service conditions. It will be seen from Fig. 1 that the shells are carried on a channel iron base which is fitted with pins to locate them in the proper relation

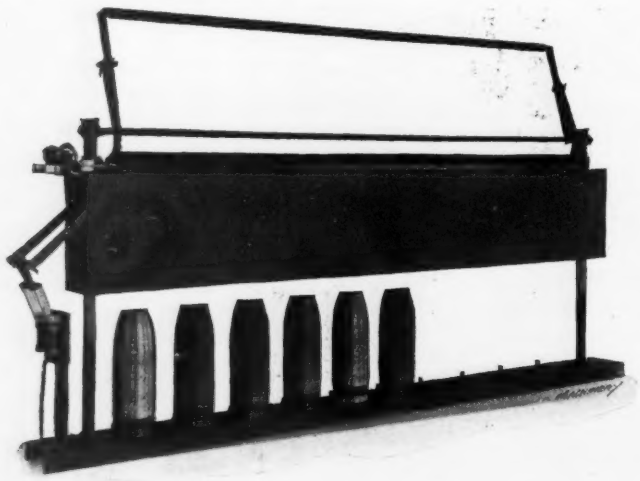


Fig. 1. Consolidated Baking Oven with Hood raised to show Method of locating Shells

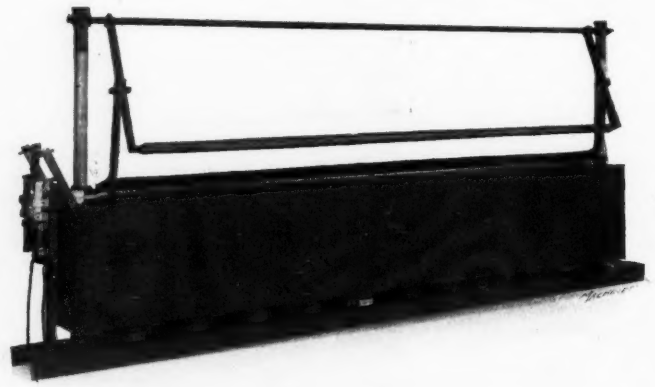


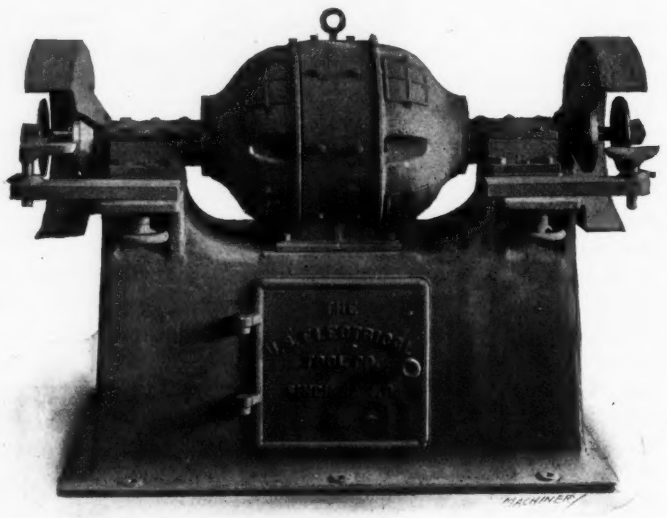
Fig. 2. Shell Baking Oven with Hood lowered over Shells

to the heating elements which are carried inside the hood. During the time that the shells are being baked, the hood is dropped to the position shown in Fig. 2; this hood is made of sheet metal and lined with asbestos to retain the heat.

When the hood is lowered the heating elements are in the correct position in the shells so that the heat is most effectively applied. As a result, an economy is effected in the amount of current required to operate the oven. The baking can be done in from one to one and one-half hour. Another feature of the oven is the automatic operation of the control switch which throws on the current when the hood is lowered over the shells, and cuts it off when the hood is raised. This oven can be built for baking any type of high-explosive shell and for operation on either alternating or direct circuits of any voltage up to 600 volts.

UNITED STATES ELECTRICAL GRINDER

The United States Electrical Tool Co., 6th Ave. and Mount Hope St., Cincinnati, Ohio, is now building the electrical grinder illustrated herewith, which has been especially designed to meet the requirements of heavy grinding operations in machine shops, railroad shops, and foundries. The spindle bearings are of the ring-oiling type and lined with babbitt; they are designed to be as nearly dust-proof as it is possible



United States Electrical Grinder built for Heavy Duty

to make bearings of this type. The machine may be equipped with either a direct- or alternating-current motor. The direct-current motor furnished with the grinder is of the four-pole variable speed type; and the alternating-current motor is a single-speed unit made by the Westinghouse Electric & Mfg. Co.

The machines are made in two sizes driven by 5 and 7½ horsepower motors, respectively. The 5 horsepower machine is equipped with wheels 18 by 3 inches in size, the length of the wheel spindle is 62 inches, and the weight of the machine is 1600 pounds. The grinder driven by a 7½ horsepower motor carries wheels 24 by 4 inches in size, and the weight

of this machine is 1850 pounds. Both sizes of machines are manufactured for use on direct-current circuits of 110, 220 or 550 volts; or for use on alternating-current circuits of 220, 440 or 600 volts, of two or three phase.

NIAGARA FORMING PRESS

The Niagara Machine & Tool Works, Buffalo, N. Y., has recently developed a line of forming presses, one size of which is illustrated in Fig. 1. These machines are intended for use in forming and bending sheet metal up to No. 20 gage, and find

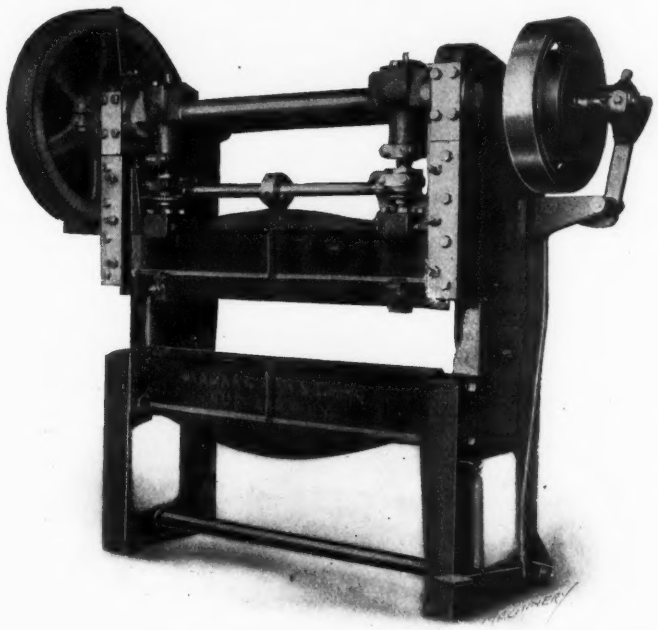


Fig. 1. Niagara Forming Press for Use in the Manufacture of Sheet Metal Furniture

application in the manufacture of metal furniture, lockers, window sash, shelving, filing cases, portable buildings, and a variety of other sheet metal products. Fig. 2 shows a set of three dies of the type used on these machines, and Fig. 3 illustrates examples of work produced with these three dies. The chief claim made for these Niagara forming presses is in regard to the rapidity with which the work can be done.

The bed and cross-head have machined recesses which are in perfect alignment with each other so that no time is lost in setting the dies sideways. The cross-head has a stroke of 3 inches so that dies of different heights can be used; and the housings have a gap 2½ inches deep to facilitate handling stock. The drive is arranged over head, making the dies accessible from the rear as well as from the front, and the motion

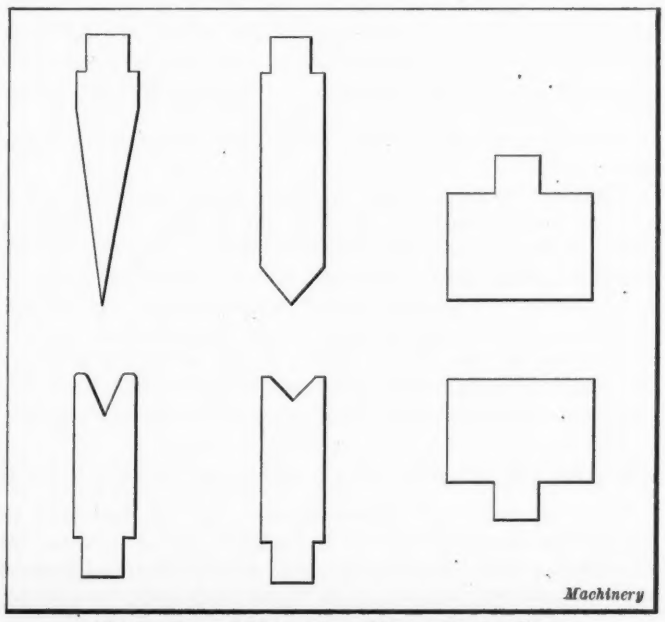


Fig. 2. Type of Dies used on Niagara Forming Press

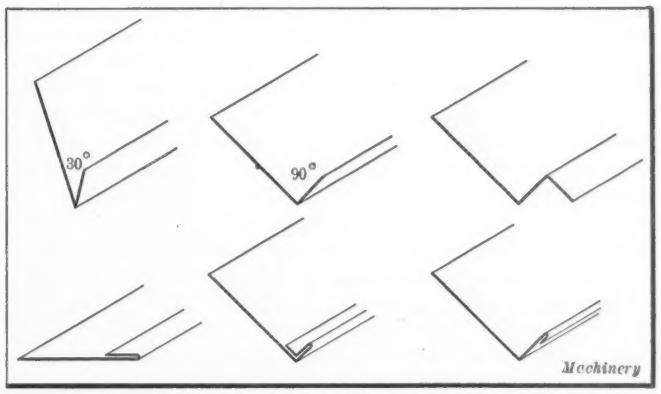
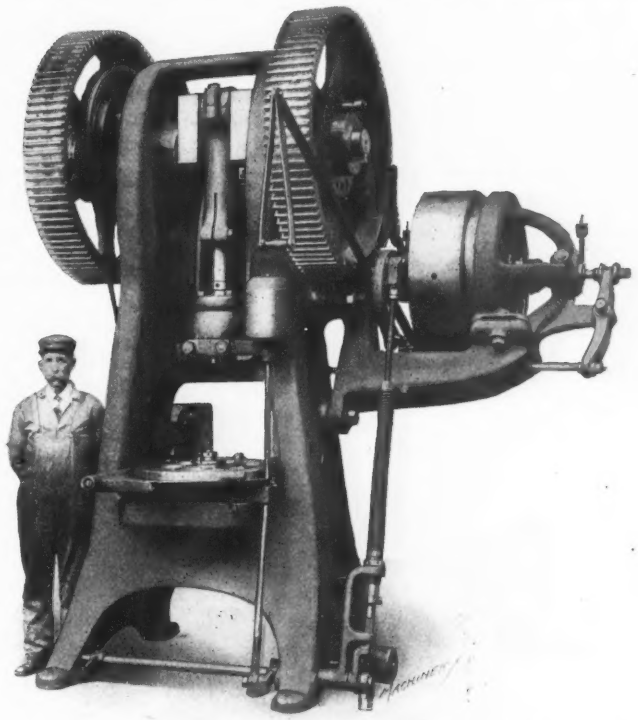


Fig. 3. Examples of Work produced by Dies shown in Fig. 2

of the machine is controlled by a friction clutch operated by a hand-lever or foot-treadle. The machine can be started or stopped at any point of the stroke. This line of forming presses comprises three different sizes with capacities of 37, 49, and 61 inches between the housings.

FERRACUTE DIAL FEED ATTACHMENT FOR CARTRIDGE CASES

The Ferracute Machine Co., Bridgeton, N. J., has recently perfected an automatic dial feed attachment for use in cupping and redrawing cartridge cases and other sheet metal shells, the attachment being used in connection with straight-sided presses developing pressures from 100 to 200 tons. The



Ferracute Automatic Dial Feed Attachment for Use in drawing Cartridge Cases

accompanying illustration shows a 100-ton Ferracute press equipped with one of these attachments; the dial has six recesses, and in designing the attachment it was necessary to make provision for aligning each successive recess with the ram to insure the entrance of the punch into the partially drawn shell. Pressure applied on the treadle caused the press to stop instantly in any position of its stroke.

The dial has an intermittent motion, being at rest while the press makes its stroke; and a cam on the main shaft imparts motion to the rack which revolves the dial yoke. A second cam on the main shaft operates the dial locking mechanism which consists of a lever with a wedge-shaped end that fits into one of six notches in the circumference of the dial. Connected to the locking mechanism there is an "interrupter" and when the locking plunger is in place in a notch in the dial, which insures the proper alignment of the ram and

recess in the dial, the interrupter prevents a weighted rod from descending; but if by any mischance the locking plunger fails to enter its notch, this interrupter changes its position and allows the weighted rod to descend and depress the treadle, thus instantly stopping the press and preventing damage to the tools. After the cause of trouble has been ascertained and corrected, the press may be made to complete its stroke by pulling down the handle strap; the rise of the ram elevates the weighted rod to its normal position and the treadle and treadle rod also return to their first position.

The press is equipped with a combination friction clutch and brake. Pulling down the hand-lever connects the power to the shaft and imparts motion to the press, while depressing the treadle releases the clutch and applies the brake. It will be evident from this description that the machine is under perfect control in any position of its stroke. There are several adjustments that give accuracy to the motion of the dial. For instance, the amount of rotation of the dial may be regulated by means of a roller at the top of the yoke, where setscrews are provided to obtain the exact adjustment that is required. The motion is also controlled by a brake which is automatically released at the time that the dial is locked. An eccentric adjustment provides for obtaining an accurate relation between the locking plunger and the successive notches in the dial. Although this press was primarily designed for continuous action, a press equipped with this dial feed attachment may be used intermittently, *i. e.*, it may be automatically stopped at the end of each stroke. When running continuously the production is twelve shells per minute.

VAN AUKEN DUPLEX HACKSAW

A departure from the usual practice in designing hacksaw machines has been made by the Clarence E. Van Auken Co., 216 N. Clinton St., Chicago, Ill., in its duplex high-speed hacksaw illustrated herewith. It will be evident that the machine is provided with two saw blades, and these move up and down together; one blade cuts on the down stroke and the other on the up stroke, making the operation continuous. The saws are fed alternately into the stock and released on the idle stroke.

Inside the frame of the machine there is a reservoir which is

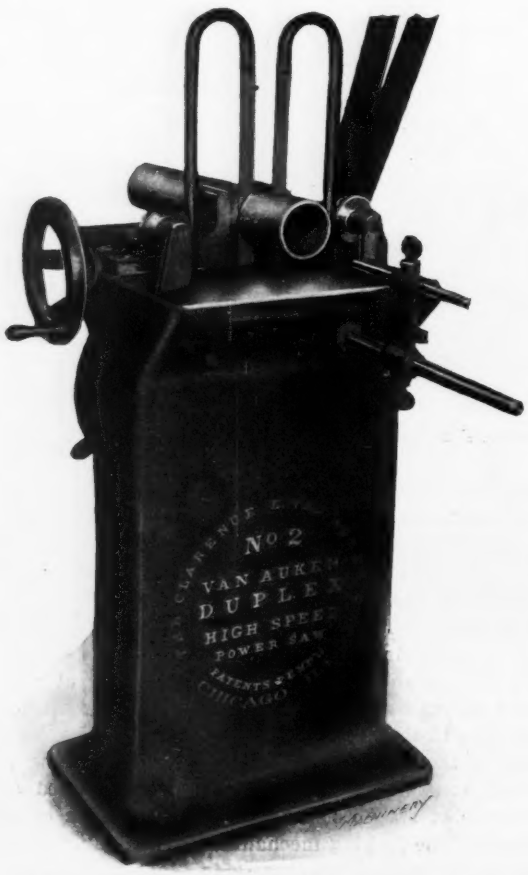


Fig. 1. The Van Auken Duplex Hacksaw Machine

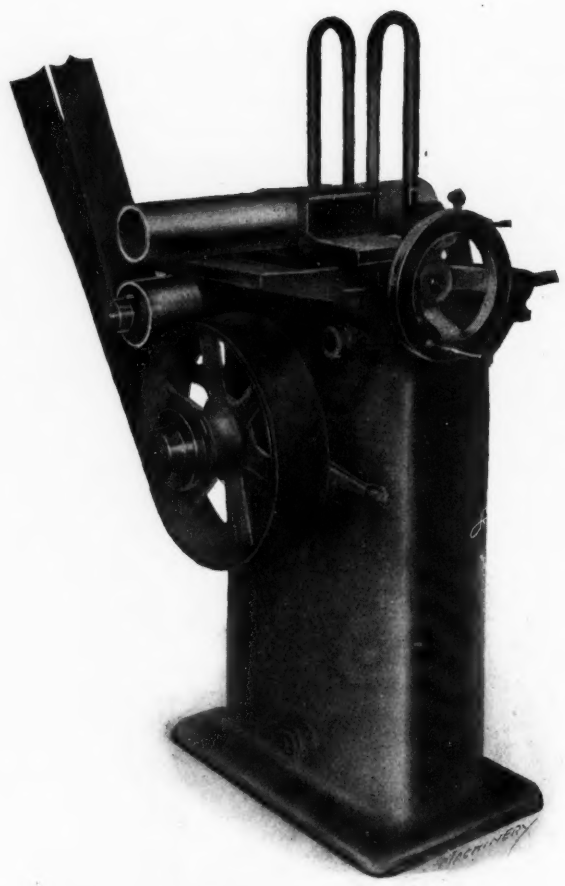


Fig. 2. Opposite Side of Van Auken Hacksaw shown in Fig. 1

partially filled with cutting compound, and the saw frames are made of heavy seamless tubing. The frames are provided with ball check valves at their lower ends. As the saw frames work up and down, the cutting compound is forced up through the tubular frames and allowed to run down the blades, so that a copious flow is supplied at all times while the machine is in operation.

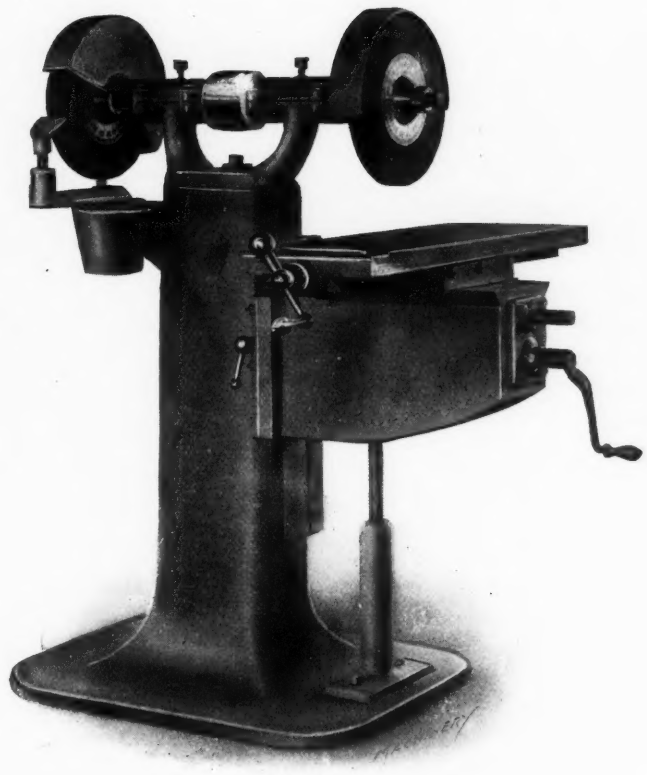
These saws can be operated at 270 strokes per minute, and it is claimed that they cut twice as fast as an ordinary hacksaw machine because there are two blades working simultaneously, and four times as fast as a machine on which no cutting compound is delivered to the work owing to the increased speed which is made possible by the manner in which the cutting compound is delivered to the saws.

The machine is driven through a positive clutch and is equipped with an automatic stop, adjustable feed and a stock gage. The screw which operates the vise jaws is threaded right- and left-hand so that both jaws move and hold the work in a central position. A top clamp is provided for holding short pieces, and the handle which operates the vise can be placed on either side of the machine. The saw frames are operated by the usual crank cross-head and guide, which are located in the reservoir inside the column of the machine so that they require no further provision for lubrication.

The machines are made in two sizes, known as Nos. 2 and 3. The No. 2 machine has a capacity for cutting work up to 4 by 4½ inches in size; the length of stroke is 6½ inches; the length of blades used, 12 inches; the floor space occupied, 10 by 16 inches; and the net weight of the machine, 145 pounds. The No. 3 machine has a capacity for cutting work up to 8 by 8 inches in size; the length of stroke is 7½ inches; and the length of saw blades used, 17 inches. These machines can be furnished with individual motor drive when so required.

LA SALLE PLAIN AND SURFACE GRINDER

The No. 3 plain and surface grinder recently developed by the La Salle Machine & Tool Co., La Salle, Ill., is intended for general shop and tool-room use and has been designed to meet the requirements of those users whose work calls for a larger and more rigid grinding machine than the tool of this type



Plain and Surface Grinder made by the La Salle Machine & Tool Co.

formerly manufactured by this company, which was illustrated and described in the February, 1912, number of MACHINERY. The spindle is made of steel and runs in babbitted bearings which are reamed in such a way that perfect alignment is assured. The vertical feed-screw is provided with a graduated dial which reads in thousandths of an inch, and smaller sub-divisions can be readily estimated when such a degree of accuracy is required. The transverse and longitudinal movements are obtained by a screw feed driven by liberally proportioned cranks which provide a smooth uniform motion. All bearing surfaces are carefully protected from dust and dirt, and the ways are hand-scraped to furnish a perfect bearing. The regular equipment of the machine includes two 12 by 1 by 1 inch grinding wheels, a countershaft, wheel guards, tool rest and a water pot.

The principal dimensions of the machines are as follows: Distance between grinding wheels, 25 inches; working surface of table, 10 by 28 inches; maximum longitudinal movement, 25 inches; maximum transverse movement, 8 inches; maximum vertical travel, 10 inches; spindle speed, 1400 R. P. M.; height to center of spindle, 42 inches; floor space occupied, 63 by 46 inches; and weight of machine with countershaft, 780 pounds.

OLIVER SAWING, FILING AND LAPPING MACHINE

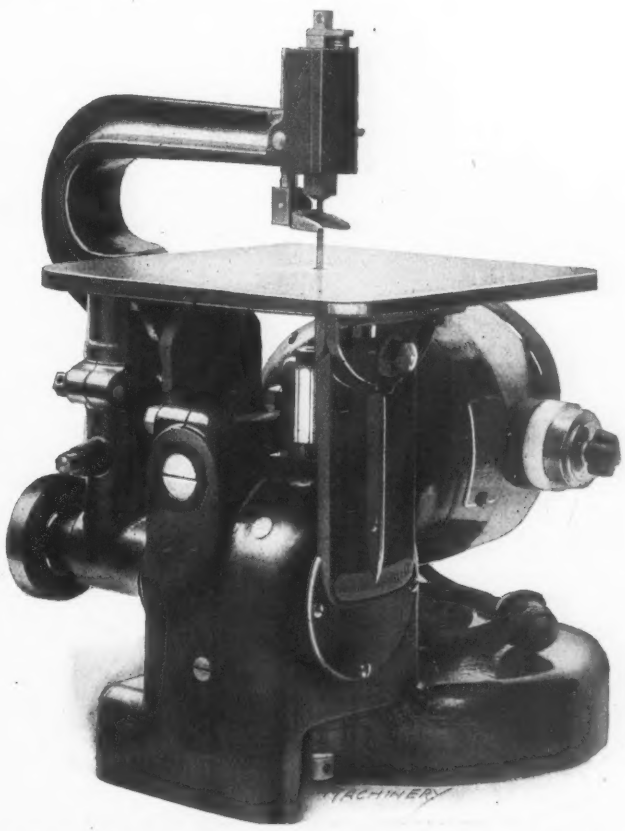
For use in shops engaged in the making of dies or instruments, or for shops where experimental work is being done, the Oliver Instrument Co., Detroit, Mich., has developed the sawing, filing and lapping machine which is illustrated and described herewith. It is particularly adapted for following irregular outlines; for instance, in making a blanking die the stock is removed by sawing out the material close to the outline, leaving an opening with the proper clearance and with a minimum amount of metal to be removed by filing. It will be evident from the illustration that the desired clearance is obtained by setting the table to the proper angle. An overarm supports the saw or file at the upper end to prevent it from being deflected from the work.

Another typical application of the machine is in sawing out plain or irregular shapes from sheet metal or flat stock, and after the sawing operation has been completed such parts may be finished to exactly the required outline by filing. The correction of an inaccuracy in a hardened die or similar part may be mentioned as a typical example of the application of the machine for the performance of lapping or stoning operations. For this purpose, either a lap or a special oil-stone may be employed, which is so supported that the maintenance of the proper clearance angle and straightness of the work is assured.

The saw, file or lap used on the machine is clamped in a special collet carried by the lower ram, and the upper end is held and guided by a similar collet mounted in a slide that reciprocates in the over-arm. The over-arm does not reciprocate, and a coil spring acts on the slide to provide an initial tension on the saw blade. The tool may be quickly released from the slide and the over-arm swung to one side to provide for removing or replacing work on which it is necessary to operate in a hole in the center of the work. Special reinforced oil-stones have been developed for use on this machine, which are held and guided in the same way as the saws and other tools. When used as a filing machine, the over-arm may be used as an upper guide for thin files or where extreme accuracy is required; or it may be swung aside or entirely removed when the machine is handling rough work.

Either a direct- or alternating-current motor may be provided for driving the machine, and it is direct-connected and entirely enclosed to exclude filings, dust and other foreign material. The power is transmitted through steel spiral gears, and the crankshaft is supported by a ball bearing which takes the thrust of the ram. The reciprocating parts are carefully balanced. The ram guides are made of cast iron and the upper guide is a separate unit, made of close grained cast iron, so that it may be replaced if necessary.

The table is 9 inches square and may be tilted to any angle up to 10 degrees in either direction from the horizontal position; it is clamped in any position by means of two bolts. The angle to which the table has been set is clearly indicated by a large scale and pointer which are shown in the illustration. A locating pin is provided, which facilitates bringing the over-arm into alignment with the lower ram, in which position it is securely clamped by a bolt. All gears, shafts, bearings and other parts of the drive are enclosed and run in oil; and the construction is such that dust, chips or other foreign matter cannot find their way into the mechanism. The equipment of the machine includes two upper and two lower collets, three oil-stones, a set of files, and a wrench for making all adjustments.



Sawing, Filing and Lapping Machine made by the Oliver Instrument Co.

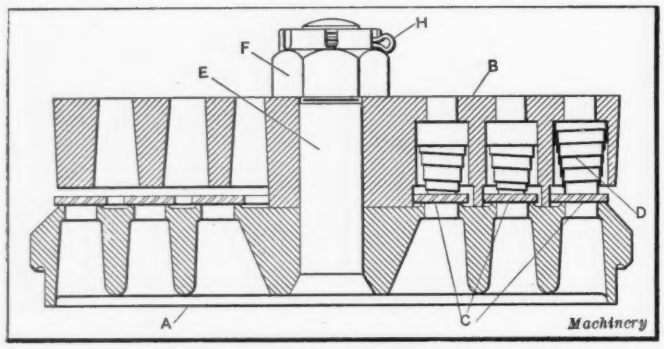


Fig. 1. "Simplate" Air Compressor Discharge Valve

"SIMPLATE" AIR COMPRESSOR VALVE

During the past decade a number of designs of flat plate compressor valves have been developed and subsequently discarded owing to their inefficiency or impracticability. These

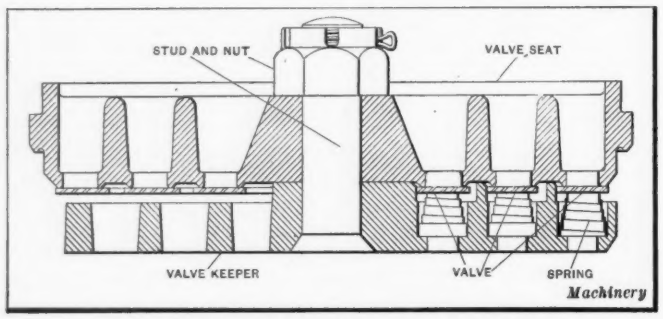


Fig. 2. "Simplate" Air Compressor Inlet Valve

designs were all remarkably similar—varying only in minor details of construction—but the "Simplate" valve which has recently been brought out by the Chicago Pneumatic Tool Co., Fisher Bldg., Chicago, Ill., represents a departure from preceding efforts to produce a valve of this type. Its chief advantages are simplicity of construction, the fact that its plates are independent of each other in action, that each plate has its individual springs, that the tension of the springs on the inlet and discharge valves differs according to the density of the air handled, and that the valve is suitable for application in all positions and under all conditions of operation.

Fig. 1 shows the discharge valve. The valve seat *A* is cast from a special alloy which possesses the properties of toughness and high tensile strength; it has circular ports as shown in this illustration. The valve seat is so machined that the raised portion, *i. e.*, the points on which the plates rest forming the joint, is very narrow so that the unbalanced area is reduced to a minimum. The keeper *B* is made of the same material and is provided with suitable ports for the free passage of air through it. The keeper also furnishes guides for the valve plates and pockets which carry the valve springs.

The valves *C* are simple concentric steel plates of uniform section, with a separate and independent plate over each port. Each plate is independently governed by its own spring so that the opening of each valve is entirely independent of the other. Should one of the plates open, the one next to it does not necessarily move; in fact, it will not move unless speed conditions demand it. This is the great advantage of having the plates independent of each other. The springs *D* are of the volute type and are made of special alloy steel, heat-treated and carefully tempered. They have the proper tension for the discharge and inlet valves, so as to effect the most perfect valve action. The parts making up a complete valve are assembled and held together by nickel steel stud *E* and castle nut *F*, and when this nut is securely tightened in place it is firmly held by cotter-pin *H*.

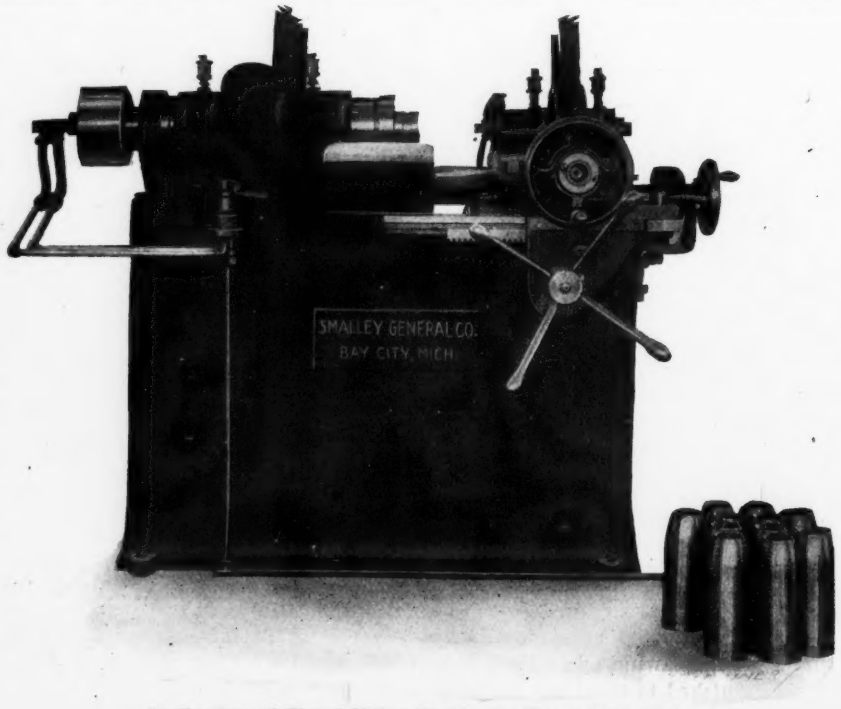
Fig. 2 shows the inlet valve, the construction of which is very similar to that of the discharge valve. It differs only in the following respects: The valve stud enters through the keeper instead of through the seat, as in the case of the discharge valve, and the keeper is of thinner construction, while the springs are also of lighter tension. On account of the difference in the thickness of these valves they cannot be reversed, *i. e.*, the inlet valve cannot be put in where the discharge valve should go, neither can the discharge valve be substituted for the inlet valve. The spring tension of the inlet valve is made very light in order to get the full benefit of the different plates when the piston speed is changed. For instance, with an inlet valve of the size shown the spring tension is so calibrated that the outer plate opens with a pressure of ¼ ounce per square inch, and 1 ounce per square inch will open the intermediate plate, while it requires 2½ ounces to open the inner plate. This illustrates the true meaning of the term "varied opening."

SMALLEY-GENERAL THREAD MILLING MACHINE

The thread milling machine which has recently been placed on the market by the Smalley-General Co., Bay City, Mich., is especially adapted for the performance of threading operations on shells. In working out the design particular attention has been paid to the development of a heavy accurate machine which is capable of standing up under the hard service conditions which are usually found in shops engaged in projectile manufacture. Although particularly developed for shell work, the machine is also adapted for threading operations on a variety of other classes of work.

The accompanying illustration shows one of the Smalley-General thread milling machines equipped for operation on 3.3-inch high-explosive shells. The shell to be threaded is held in an air-operated collet chuck, and this method of holding the work, together with the rapidity with which the machine operates, enables shells of this size to be threaded at an average rate of 1 minute and 10 seconds per shell. This rate f production applies to the average rate over a full working day. For threading larger sizes of shells a different type of chuck is used.

The head and bed of the machine are cast in a single piece which insures a rigid construction and maintenance of perfect alignment at all times; and the bed is cast with two longitudinal and two vertical cross-ties which add materially to its strength. All slides are liberally proportioned and the gears used on the machine are cut from steel; the principal



Smalley-General Thread Milling Machine for Use on Shell Work

gears run in oil and they are all guarded to provide for the safety of the operator. All bearings on the machine are bronze-bushed.

The oil supplied to the cutting tool is separated from the chips and passes through three settling tanks in the base of the machine before entering the rotary pump which carries it back to the work. Liberal sized sight-feed oil-cups are provided for lubricating all of the main bearings. The principal dimensions of the machine equipped for threading 8-inch and 9.2-inch high-explosive shells are as follows: Length of bed, 7 feet, 4 inches; width of bed, 29½ inches; width across ways, 28 inches; height from ways to center of spindle, 13½ inches; and size of main spindle bearings, 4 by 8⅜ inches. The operation of these machines is such that one man can easily attend to two machines; and as usual with thread milling machines, the thread is completed by a single revolution of the work.

"MECHANICS" UPRIGHT DRILLING MACHINE

In designing the upright drilling machine which forms the subject of this description, the aim of the Rockford Machine Tool Co., Rockford, Ill., has been to simplify the mechanism as far as possible and eliminate all parts that are likely to fail under severe service conditions. The illustrations show side views of the machine, from which a good idea of its design may be obtained. Power is supplied by a single clutch pulley 20 inches in diameter by 6 inches wide which is belted to the lineshaft; this pulley is located at the right-hand side of the machine and is shown in Fig. 1. A view of the machine from the opposite side is shown in Fig. 2, in which the cover has been removed from the change-gear box; this box is furnished with six change-gears and provides six spindle speeds ranging from 60 to 360 revolutions per minute. Fig. 3 shows a top view of the machine, together with a cross-sectional view through the feed works, and illustrates the manner in which the six available changes of feed are secured by means of six change-gears. These feeds range from 0.010 to 0.060 inch per revolution. All driving gears are of 4 pitch, and have a face width of 2½ inches. The feed gears are 6 pitch and have a face width of 1½ inch.

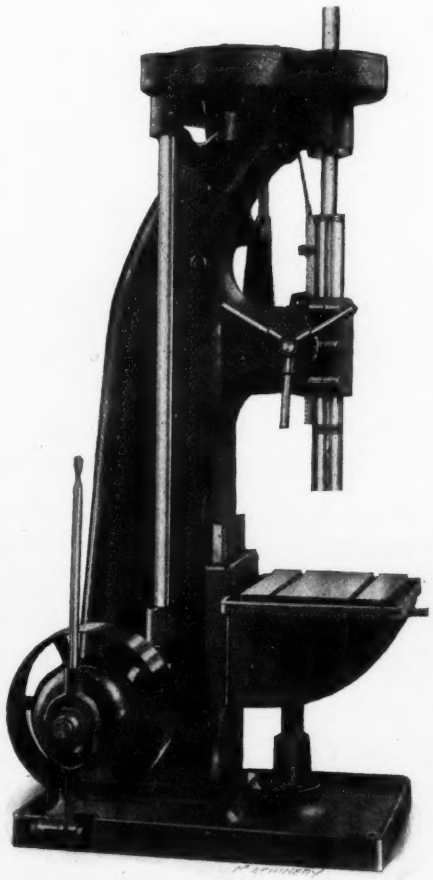


Fig. 1. Left-hand Side of Machine showing Single Pulley Drive

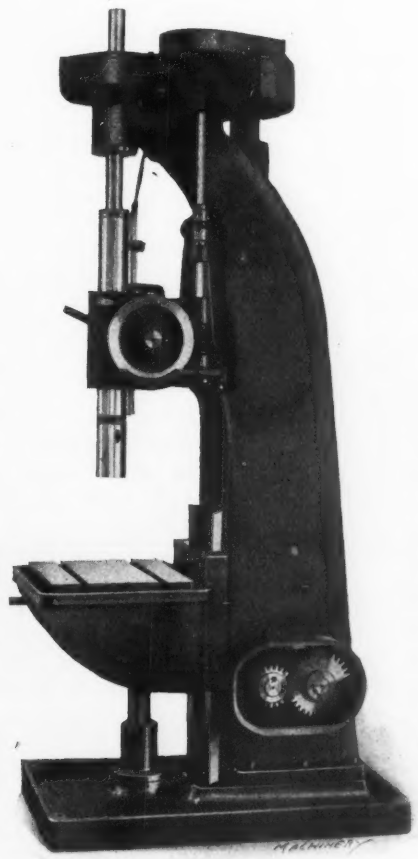


Fig. 2. Right-hand Side of Machine showing Change-gear Box with Cover removed

The principal dimensions of the machine are as follows: Distance from face of column to center of spindle, 12 inches; maximum distance from spindle to table, 28 inches; length of power feed, 14 inches; diameter of spindle in sleeve 2⅜ inches; diameter of spindle above sleeve, 2¼ inches; diameter of sleeve, 4 inches; diameter of base of spindle, 3⅞ inches; diameter of vertical driving shaft, 2¼ inches; working surface of table, 18 by 24 inches; width of steel rack on spindle sleeve, 1¾ inch; size of spindle driving gear, 12 inches in diameter by 2½ inches face width and 4 pitch; vertical adjustment of table, 16 inches; available feeds, 0.010, 0.015, 0.020, 0.030, 0.040, and 0.060 inch per revolution; available spindle speeds, 60, 120, 180, 240, 300 and 360 revolutions per minute; size of driving pulley, 20 inches in diameter by 6 inches face width; speed of driving pulley, 400 revolutions per minute; and approximate weight of machine, 3600 pounds.

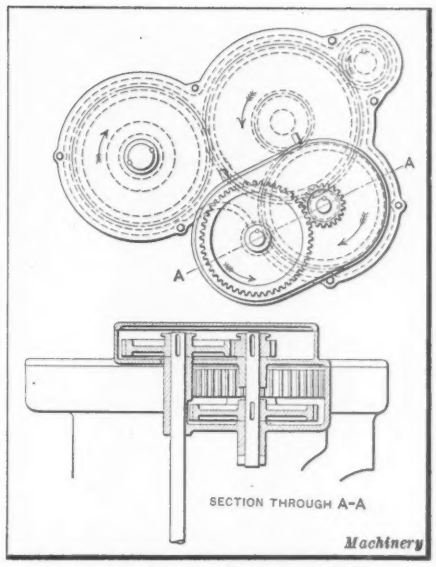


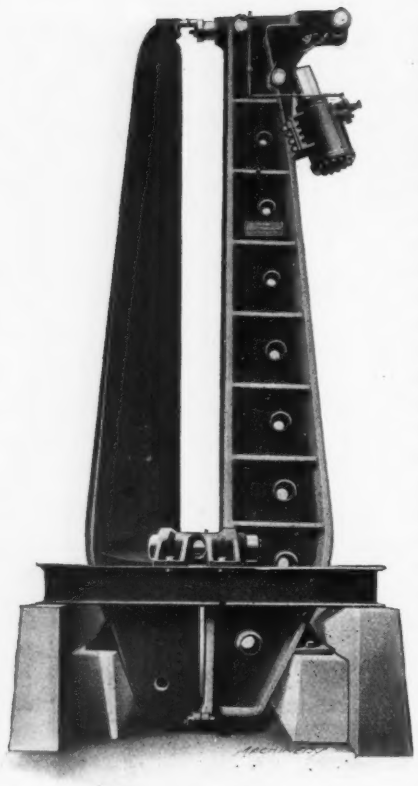
Fig. 3. Top View of Machine and Cross-section through Feed-box

VULCAN PNEUMATIC RIVETER

The pneumatic riveter illustrated and described herewith, has recently been placed on the market by the Hanna Engineering Works, and the Vulcan Engineering Sales Co., 2063 Elston Ave., Chicago, Ill., has the sales agency for the machine. The claim is made for this machine that it is the largest pneumatic riveter ever constructed; it has a reach of 21 feet and is capable of exerting a pressure of 100 tons on the rivet die when operated with air at a pressure of 100 pounds per square inch. An idea of the size of the machine will be appreciated from the fact that its weight is 40 tons.

In designing this machine, toggles, levers and guide links have been combined in a simple form to give a large opening of the toggle joint movement with gradually increasing pressure until the desired pressure has been obtained. After attaining the required pressure, there is a simple lever movement through a considerable space under approximately the maximum pressure. This space is sufficient to assure pressure being applied to the rivet, and after the machine has once been adjusted for a certain length of rivet and thickness of plate, it will require no further adjustment for ordinary variation in the length of the rivets, the size of the holes or the thickness of the plates. It is claimed that the results obtained with this pneumatic riveter are the equivalent of those produced with hydraulic machines.

The machine is adapted for the performance of riveting operations on boilers, tanks, and structural work. It is furnished with a cylinder in which the piston has a stroke of 22 inches to accomplish a travel of 5¾ inches of the riveting die. As in the smaller machines of this type, the toggle action is in operation during the first half of the piston travel, *i. e.*, during the first

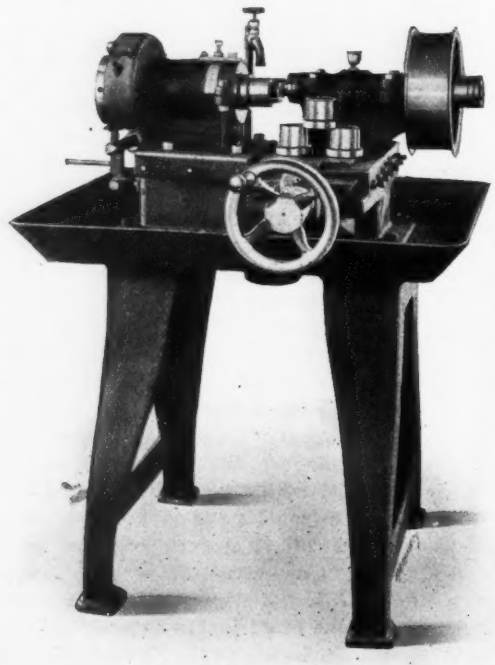


Large Pneumatic Riveter made by the Hanna Engineering Works

movement of 11 inches, which corresponds to approximately the first 4¾ inches of die travel. At this point the operation of the mechanism automatically changes to a simple lever action which holds the rated pressure capacity of the machine at the riveting die, which is practically uniform for the last 1 inch of die travel. By the use of a pressure regulating valve in the supply line which delivers air to the riveter, the pressure of the air at the cylinder may be quickly changed to vary the pressure developed by the riveting die, to produce any pressure which it may be deemed advisable to use on the work which is being handled.

HOLDEN-MORGAN SOCKET THREAD MILLER

The Holden-Morgan Co., Toronto, Canada, has recently added to its line a thread milling machine which is especially adapted for milling the outside thread on the fuse sockets of all types of high-explosive shells up to the 6-inch size. The socket to be threaded is placed on a special chucking device and the threading operation is then completed without requiring any further handling of the work. This machine produces a clean, accurate thread, and the operation is completed in from 1½ to 2 minutes, according to the size and type of shell for which the socket is intended. The machine is provided with stops so that it may be readily set for operation on any class of work; and the method of operation is so simple that unskilled labor may be utilized with satisfactory results. No countershaft is necessary as the machine may be belted direct to the lineshaft. It is customary to set the machines up in tandem, and a battery of machines may be tended by a single operator. The features are simplicity of design, rigidity of construction, and efficiency of operation when handled by unskilled labor. The A. R. Williams Machinery Co., Ltd., 64-66 Front St., W., Toronto, Ontario, Canada, has the selling agency for this machine.



Holden-Morgan Socket Thread Miller sold by the A. R. Williams Machinery Co.

UNITED "LONG RANGE" ARBOR PRESS

The United Engine & Mfg. Co., Hanover, Pa., has developed what is styled a "long range" arbor press to meet the demand for a press with ample capacity for handling the great variety of work which comes to garages, general repair shops and machine shops in which arbor presses are used. The two most noteworthy features of this machine are as follows: First, one man can raise or lower the table to any desired position in less than a minute, which is a valuable feature on a machine adapted for work in which the size varies considerably; second, the sliding V-block on the table instantly adjusts itself to suit all different sizes of arbors and also gives ample support to the hub or bushing no matter how thin it may be.

"Long Range" Arbor Press made by the United Engine & Mfg. Co.

The rack and pinion method is employed for operating the ram, which experience has shown to give very satisfactory results due to the efficiency, durability and speed of operation of this type of mechanism. The suitability of the term "long range" arbor press for this machine will be appreciated when it is known that the capacity is for work ranging from pieces of large diameter down to arbors or shafts of considerable length. The construction has been worked out in such a way that the press is quite rigid and strong enough to stand up under all classes of work for which it is adapted. It is a self-contained unit which is bolted to the floor and requires no further support.

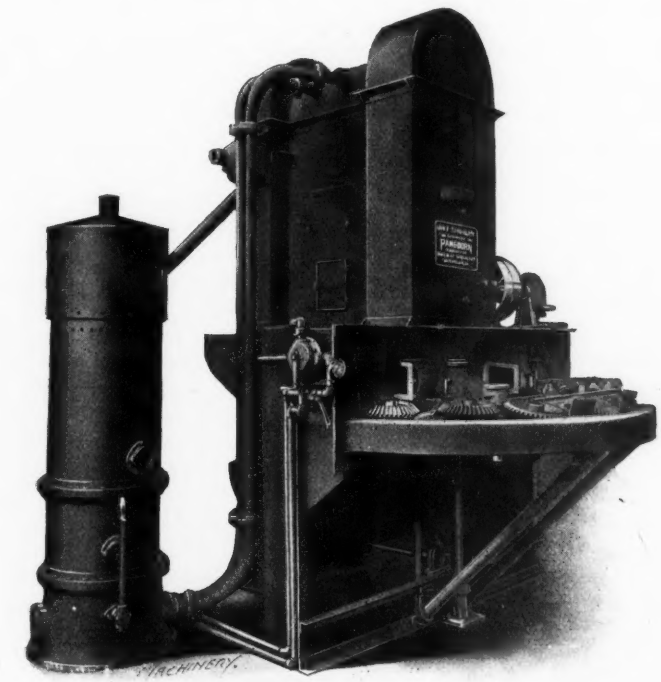
The principal dimensions are as follows: Height of center of operating lever from floor, 48 inches; capacity between standards, 21 inches; maximum capacity under ram, 40 inches; width of opening in table, 3¾ inches; travel of ram, 12 inches; floor space occupied, 24 by 22 inches; ratio of leverage, 100 to 1; pressure capacity, 10 tons; and weight of machine, 375 pounds.

PANGBORN ROTARY SANDBLAST MACHINE

The rotary table sandblasting machine which has recently been developed by the Pangborn Corporation, Hagerstown, Md., is primarily intended for cleaning medium and small sized castings which cannot be satisfactorily handled in the

barrel type of sandblast; and the machine also finds application in certain cases where it is not desirable to employ the hose type of sandblast. In using this machine, the castings are laid on the table which rotates in order to carry them under the blast, and with this method of handling there is practically no possibility of breaking the castings. The blasting compartment is located at the back of the machine and shielded by a series of rubber curtains which effectually prevent any sand or dust from escaping. The sand is delivered by rotating nozzles which are set at a slight angle and pass over the entire surface of the table. After striking the work, the sand falls through the grate bars of the table to a "boot" from which an elevator returns it to the sandblast. The refuse is thoroughly separated from the sand each time it is used, and the continuous operation of the elevator also provides for continuous operation of the machine.

All moving parts of the machine are enclosed to protect them from damage and to provide for the safety of the operator. The machine is designed along heavy lines and particular care has been taken in selecting the materials from which all parts are made, so that the required strength and durability are provided. The levers which control the machine are centrally located within easy reach of the operating position. It will of course be evident that in using this machine the operator merely loads the castings onto the rotating table which carries them under the blast, and removes the clean castings as the table carries them back past the operating position. In most cases the castings remain on the table while it makes two complete revolutions, and are turned



Pangborn Rotary Table Sandblast

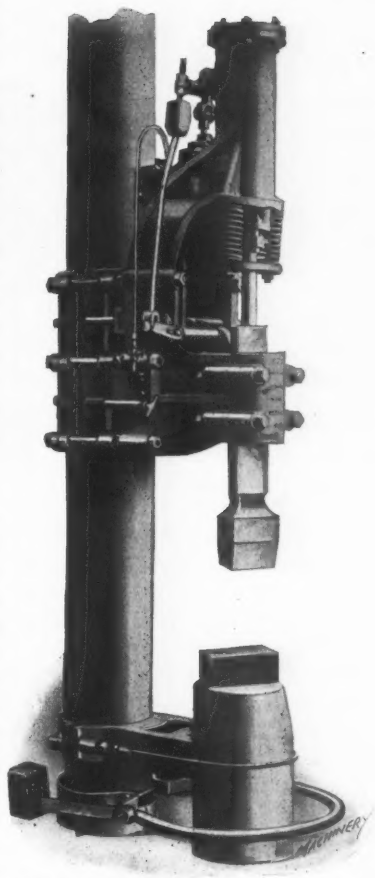
over after the first revolution is completed in order to be cleaned on the opposite side. It takes about five minutes for the table to make one complete revolution. The machine is built in two sizes with tables 90 and 70 inches in diameter; the larger machine is provided with two nozzles and the smaller has but one nozzle.

VULCAN POST HAMMER

The extremely high price of tool steel at the present time has led to the introduction of numerous economies in the use of this material. A case in point is found in the practice which has arisen in many shops of drawing down short pieces of tool steel, which were formerly scrapped, so that they can be used for small lathe tools and for cutters used in toolholders. The Vulcan Engineering Sales Co., 2063 Elston Ave., Chicago, Ill., has recently placed on the market an improved type of post hammer which is particularly adapted for doing this work in addition to the performance of general light forging operations. This machine is manufactured by the Q. M. S. Co. of Chicago.

An important feature of this hammer is that it is of compact construction and so designed that the blacksmith can easily control it without requiring the assistance of a helper. The machine can be operated by either steam or compressed air to suit the requirements of the user.

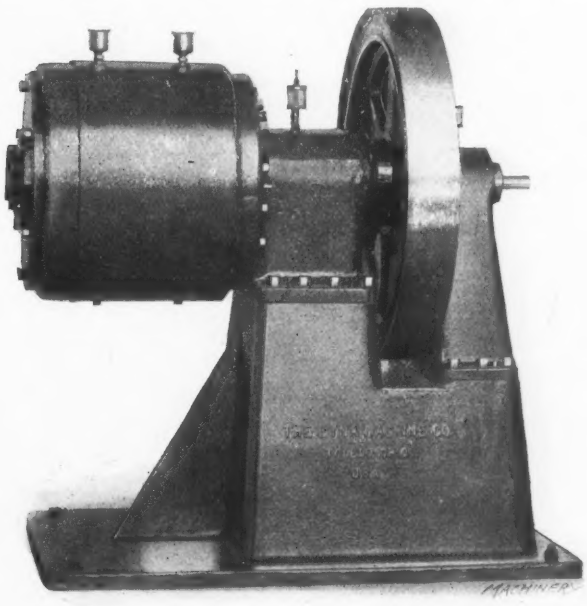
A patented valve movement on the hammer insures perfect control; if the treadle is brought down to the limit of its motion the ram will give a hard full blow, while if the treadle is only depressed part way the ram will deliver a succession of hard or light blows according to the position of the treadle. The change from one weight of blow to another may be made very rapidly.



Vulcan Post Hammer which can be operated without the Assistance of a Helper

ETNA COLD SWAGING MACHINE

The Etna Machine Co., Toledo, Ohio, is now building a line of heavy-duty swaging machines which are noteworthy on account of their exceptionally long die capacity. The range of operations for which the machines are adapted covers a wide field and allows for handling a great variety of parts from solid or tubular stock. Dies up to 18 inches in length are used on the machine. An idea of the productive capacity may be gathered from the fact that bicycle forks are produced in one operation at the rate of 300 or more per hour. Stock up to 4 inches in diameter can be swaged on this machine, and as the shaft is hollow, tubes of any length can be passed through the machine. Owing to the way in which the design of the shaft and die housing has been worked out,

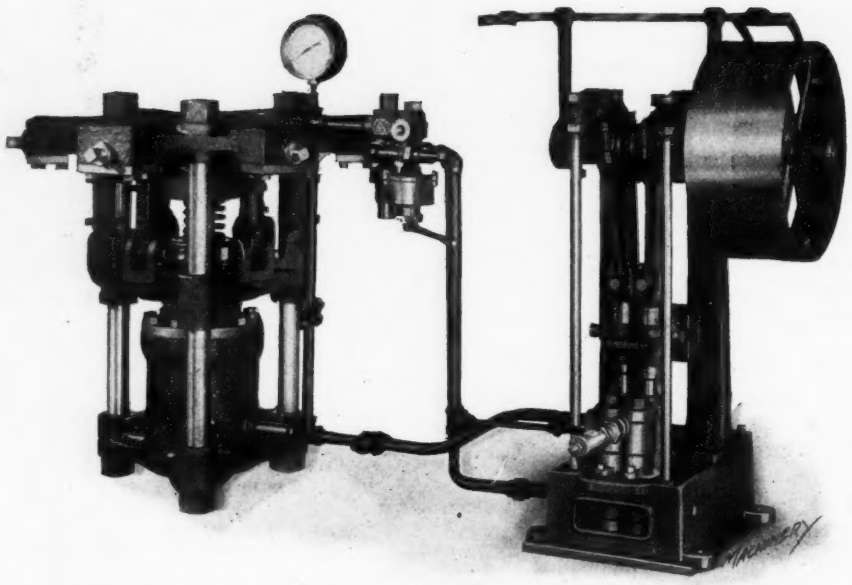


Etna Cold Swaging Machine for Stock up to 4 inches in Diameter

a bright smooth finish is produced on the work.

The machine shown in the accompanying illustration is used for tapering tubes 18 inches in length by 1¼ inch in diameter. The principal working parts are contained in the drum which is bolted to the housing. This drum is lined with alloy steel rings 1¼ inch in thickness by 10⅞ inches inside diameter, and inside these rings there is a cage containing ten hardened steel rolls which revolve and roll over the die-blocks. These die-blocks, in their turn, cause the dies to hammer the work. All working parts inside the drum are made of carefully selected materials which provide ample strength without danger of breakage. The shaft and housing for the dies is made in one piece from a special steel forging, and the shaft is lined with high-grade phosphor-bronze bearings. The flywheel is 36 inches in diameter by 5½ inches face width and is of ample weight to give the required power and stability to the machine. Oil-cups deliver lubricant to all working parts, and these cups are located in plain sight and within easy reach of the operator. The oiling facilities are made as simple as possible.

The following are the principal dimensions of the machine: size of flywheel, 36 inches in diameter by 5½ inches face width; size of bronze bearings, 4½ by 7 inches; outside diameter of die housing, 7 inches; size of rolls, 1 15/16 inch by 18 inches; number of rolls, 10; size of drum, 24 inches in diameter by 20 inches long; size of swaging die, 2⅝ by 1½ by 18 inches; speed at which machine is operated, 300 R. P. M.; floor space occupied by machine, 37 by 54 inches; and net weight of machine, 5500 pounds.



Metalwood Hydraulic Shell Banding Press for Shells from 3 to 6 inches in Diameter

METALWOOD BANDING PRESS

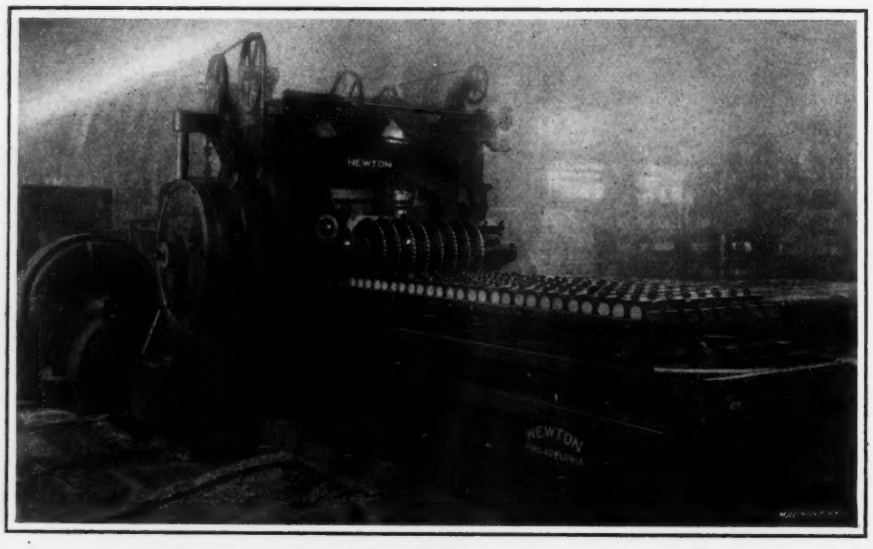
A hydraulic press for compressing the copper bands onto shells from 3 to 6 inches in diameter is one of the recent products of the Metalwood Mfg. Co., Detroit, Mich. It will be seen that the hydraulic cylinder is located at the base of the press. The pressure is transmitted through a toggle mechanism, and means of adjustment are provided for regulating the amount of pressure and the length of stroke. The compression of the copper band is effected by six concentric dies which converge upon the common center and form a complete circle when closed, which is of the required diameter of the band.

The press is driven by a Metalwood vertical duplex pump, or it may be driven from an accumulator; the capacity is 20 strokes per minute. All bearings in the pump are lined with phosphor-bronze, and both the press and pump are controlled by a Metalwood single-lever valve which governs the pressure applied and the return of the dies to the starting position. It will be seen that all working parts are fully enclosed, but the dies are readily accessible so that they may be quickly changed for working on various sizes of shells. The toggle mechanism through which the pressure is applied, is arranged with adjustment so that the pressure applied to the dies can be regulated to suit the pressure applied in the hydraulic cylinder. The complete weight of the machine is 3390 pounds.

NEWTON HORIZONTAL MILLING MACHINE

The 50-inch horizontal milling machine, illustrated and described herewith was originally designed and built by the Newton Machine Tool Works, Inc., Philadelphia, Pa., for use in milling the heaviest types of locomotive side and connecting-rods, but the unusual features of design which were called for by the company for which the machine was built have made it possible to apply machines of this type for the purpose of cutting off shrapnel blanks at a very satisfactory rate of production. The most daring departure from accepted design insisted upon by the purchaser consisted in the elimination of the cross-rail to give a clear view of the work being machined, and when this manufacturer subsequently started equipping his plant for the manufacture of shells, it was discovered that these special milling machines could be provided with circular saws and used to excellent advantage for cutting off the shell blanks because the elimination of the cross-rail had left ample clearance for the saws.

The machines are driven by a 50-horsepower motor, the width between the uprights is 50 inches, and the width of the work-table over the finished surface is 42 inches. The method of handling the work is as follows: Bars 50 inches in length are cut off from sixteen bars of steel which are stacked from three to five high for this operation on the cold saw. The 50-inch lengths are then transferred to the milling machine to be cut up into eight short forging lengths by eight inserted-tooth saw blades mounted on an arbor. The rapidity with which this cutting can be done is such that the labor cost is only twenty-five cents per hundred for the short lengths, which includes the cost of



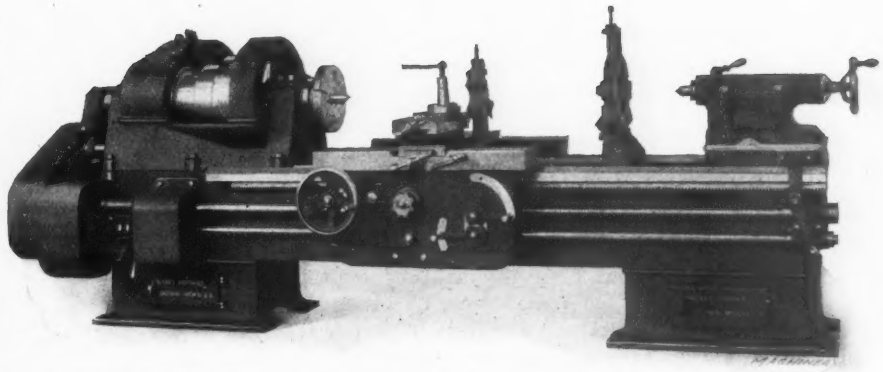
Newton 50-inch Horizontal Milling Machine that can be used as a Cold Saw

the preliminary operation of cutting the steel bars up into 50-inch lengths ready to be handled on the milling machines.

The spindle is arranged to drive a 4-inch arbor by means of a broad-faced key, the spindle being bored No. 7 Morse taper and provided with a through retaining bolt to hold the arbor in place, thus relieving the outboard bearing of all strain. The spindle is driven by a sleeve worm-wheel 35½ inches in diameter, the power being transmitted by a double set of keys. The teeth of the worm-wheel are of steep lead, and these teeth are cut in a bronze rim which surrounds the wheel; the driving worm is of hardened steel and provided with roller thrust bearings. These bearings are carried by the spindle saddle and in this way all strains are supported by the saddle and there is no tendency to transmit vibration to the saw. The spindle drive is carried through bevel and spur gears.

The feed is taken from a vertical shaft which transmits the motion through to the operating side of the machine where a gear-box provides three changes of feed of 0.100, 0.150, and 0.200 inch per revolution of the spindle. Reversible fast power traverse is also provided, by means of a friction clutch which controls the gearing employed for this purpose. One lever engages the clutch which governs the fast power traverse of the table, and the direction in which this lever is moved indicates the direction in which the table will travel. Another lever controls the clutch for the feed mechanism which is provided with an automatic trip. A handwheel provides hand movement of the table and another wheel governs the adjustment of the spindle saddle and outboard bearing which can also be raised or lowered by means of an independent three-horsepower motor.

The saddle is counterweighted and has square lock gibbed bearings on the upright, which can be adjusted by means of tapered shoes. These shoes are so arranged that it is an easy matter to detach the saddle should the necessity arise for so doing. The elevating screws for both the saddle and outboard bearing have a top and bottom bearing to maintain them in alignment at all times. The work-table is of heavy construction and is driven by a spiral rack and pinion. Three changes of feed are available for each spindle speed, as previously noted. The work-table and bed are both connected to the lubricating system and the drip pan is cast integral with the bed. The machine occupies a floor space of 21 by 15 feet and weighs 38,000 pounds.



Wickes Bros. 24-inch Engine Lathe built with Various Lengths of Beds up to 14 feet, 8 inches

WICKES ENGINE LATHE

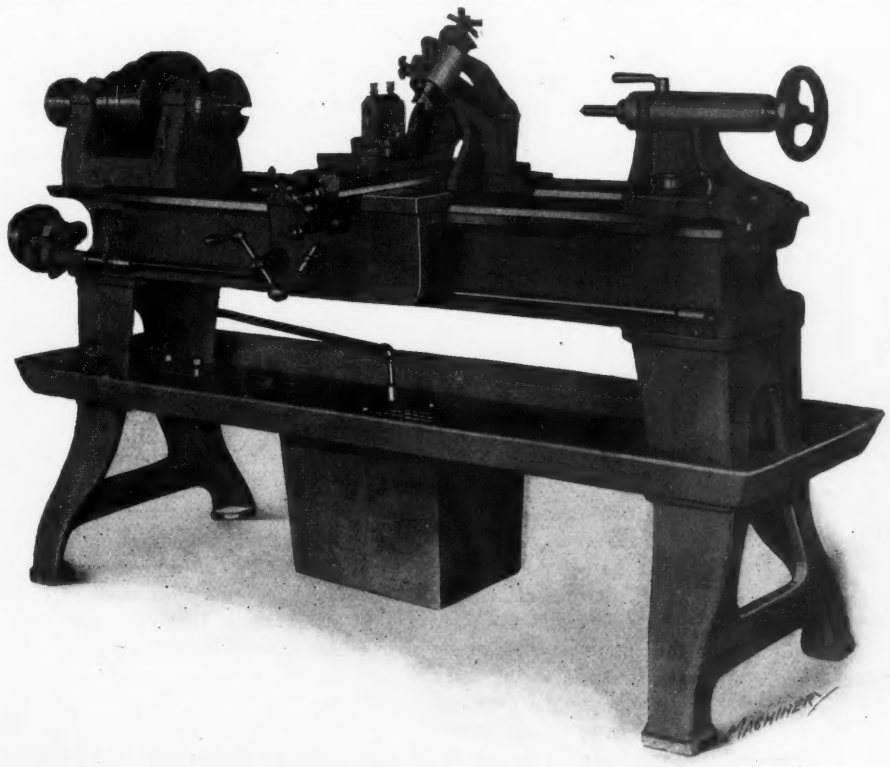
The engine lathe which forms the subject of the following description is a recent product of Wickes Bros., Saginaw, Mich., and is at present being made in a nominal 24-inch size. The lathe is of the double back-geared type and has a double plate apron; the spindle is hollow to provide for handling bar stock, the hole through the spindle being 2 3/16 inches in diameter. It will be seen that the lathe is equipped with a compound rest and change-gears for screw cutting. The regular equipment includes a large and small faceplate, steady-rest, countershaft, and the necessary wrenches. All gears are carefully enclosed to provide for the safety of the operator.

The principal dimensions of the machine are as follows: Actual swing, 26½ inches; width of driving belt, 4½ inches; range of threads which can be cut, from 1 to 18 per inch including 11½ threads per inch; approximate weight of machine, 7700 pounds. Machines of this size are built with various lengths of beds up to 14 feet, 8 inches in length.

BAUSH RIFLE-BARREL TURNING MACHINE

The barrels of military rifles are forged to approximately the required shape and are finished on the outside by different types of machines employed for the purpose. The accompanying illustration shows a special rifle-barrel turning lathe which is a recent product of the Baush Machine Tool Co., 200 Wason Ave., Springfield, Mass. Reference to the accompanying illustration will make it evident that the turning tool is carried in a substantial tool-block on the cross-slide, and that the pressure of the cut is supported by means of a back-rest. The object of the machine is to simplify the work of obtaining the required form for the rifle barrel as far as possible, and this result is obtained by having a master plate at the back of the machine which governs the form of the work.

The transverse movement of the cross-slide is governed by means of a roller which contacts with the master plate. It will be evident that in order for the back-rest to serve its purpose, the position of this rest must be adjusted to correspond to the point of action of the turning tool. This result is obtained by having the back-rest supported on a pivoted bracket, the lower end of which carries a roller which also engages with the master plate. With this arrangement, the cross-slide is given the required movement to enable the turning tool to bring the barrel



Rifle-barrel Turning Lathe made by the Baush Machine Tool Co.

to the required form, and the back-rest moves in unison with the tool, so that adequate support for the work is provided at all times. There is a stop which engages the carriage at the required point and stops both the feed and rotation of the spindle.

BAUSH INVERTED STATION TYPE DRILLING MACHINE

The station type of drilling machine which is illustrated and described herewith has been designed and built by the Baush Machine Tool Co., 200 Wason Ave., Springfield, Mass., for use in drilling the bolts and receivers of military rifles. At first sight this machine may appear similar to the multiple-spindle drilling machine of this company's manufacture, described in the November, 1914, number of MACHINERY, which was built for use in drilling the flywheels of Ford motor cars. As a matter of fact, there is a considerable difference in the design; on the earlier type of machine the drills were carried in multiple heads supported by the turret, and the work was mounted on a table supported by the base of the machine, while in the present case it will be seen that the work is supported in fixtures mounted on the turret, while the tools are carried on the base of the machine. In both cases the drive is from above, but in the case of the present machine the work revolves and the tools remain stationary; it also will be noticed that this machine takes advantage of the inverted drilling principle which is beneficial in clearing the chips from the work.

It has been mentioned that the work is mounted in fixtures supported by spindles carried in the turret, and that the work is rotated. The feeding of the drills to the work is accomplished by raising the spider on which the drills are carried. The drills increase progressively in length, in order to obtain the required depth of hole; and it will, of course, be evident that for each indexing of the work one finished part is produced. The use of various lengths of drills in this way serves the same purpose as backing out the drill at the required intervals, which is the practice in deep-hole drilling where a single drill is employed. On this machine the drills are of the oil-tube type which provides for delivering the oil direct to the point of the drill. It will be seen that the drive is provided by an electric motor carried at the top of the machine, and power is transmitted to the spindles which carry the work-holding fixture by means of a central gear which meshes with pinions carried on each of the spindles.

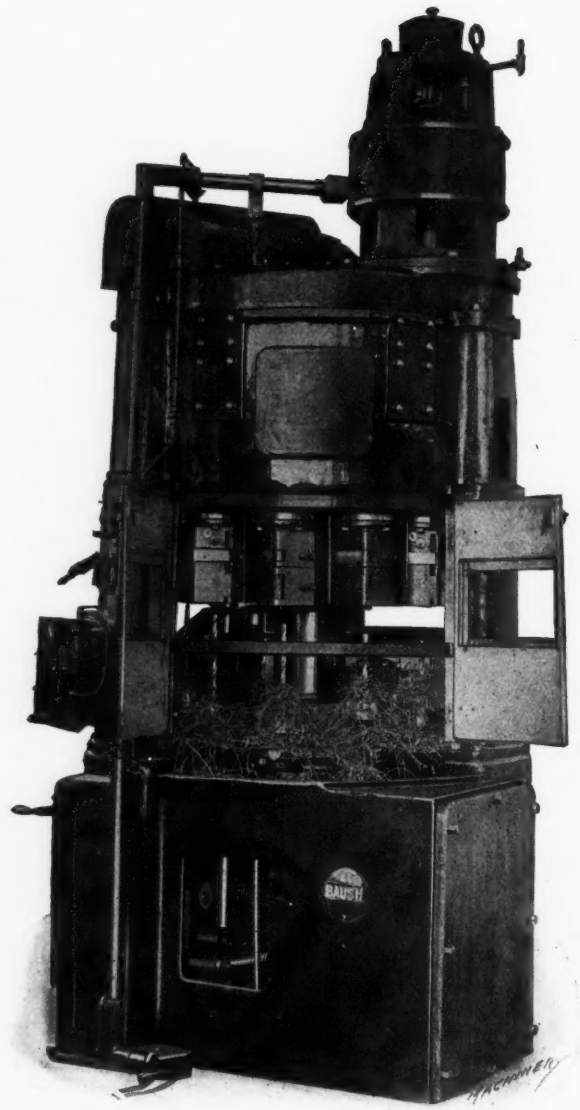


Fig. 2. View of Drills and Work-holding Fixtures

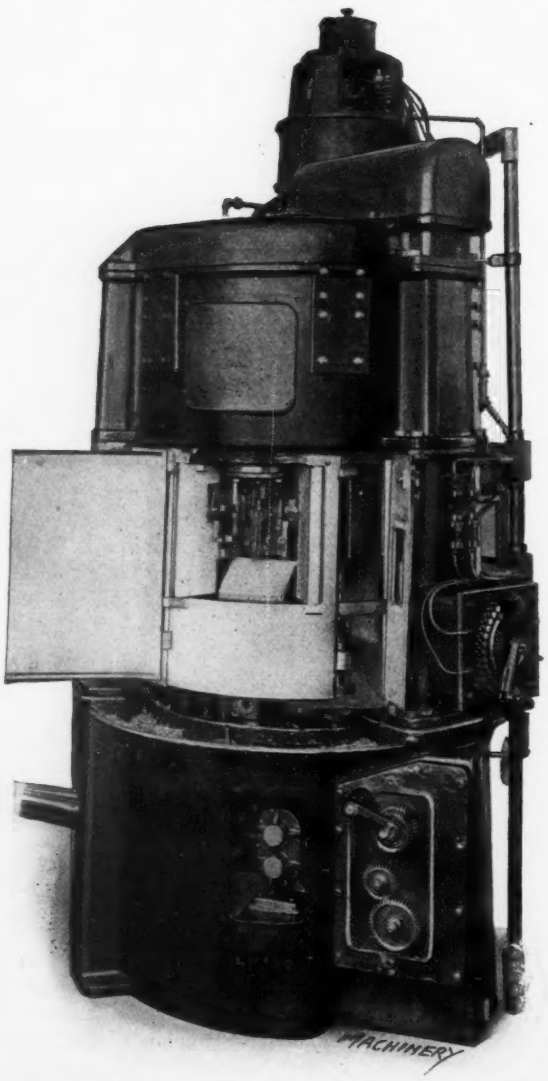


Fig. 1. Loading Station and Electrical Control on Baush Drilling Machine

In the base of the machine there is a barrel cam which provides for raising or lowering the spider which carries the drills, in order to feed the tools to or withdraw them from the work. The indexing is accomplished by rotating the turret which carries the work-spindles, and the release of the locking bolt which secures this turret in place during the performance of each drilling operation is accomplished by means of an edge cam carried at the bottom of the feed cam. This edge cam actuates a bellcrank which extends up to the top of the machine and makes connection with the locking bolt. There is one idle position on the machine, *i. e.*, a work-holding fixture under which there is no spindle. This is the loading position at which the finished product is removed and fresh blanks set up in the machine. A pull switch and a controller are located within reach of this position so that the operator has the machine under control at all times. It will be seen that doors are provided to give access to each station on the machine, and these doors are fitted with mica windows to enable a view to be obtained of the work in each position without exposing the observer to oil which would be thrown from the machine if means were not provided to guard against this trouble.

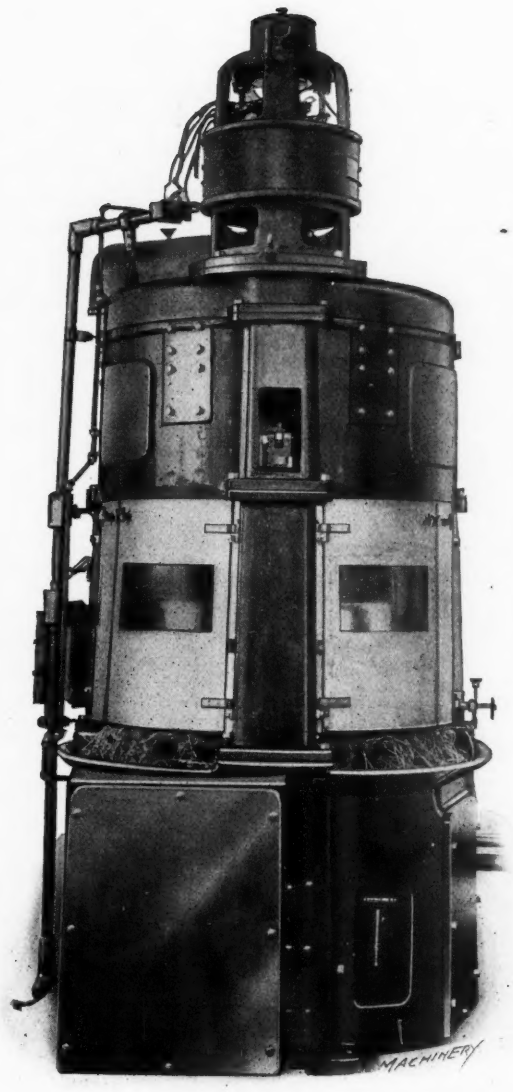


Fig. 3. Side View of Machine; note Lever that withdraws Locking Bolt

BAUSH STATION TYPE TAPPING MACHINE

The station type tapping machine which is shown in the accompanying illustration has recently been developed by the Baush Machine Tool Co., 200 Wason Ave., Springfield, Mass., for use in tapping the receivers and bolts of military rifles. To adapt the machine for tapping either of these classes of work, it is merely necessary to substitute the proper work-holding fixtures on the turret and the proper style of taps in the machine. It will be seen that the machine is arranged with single-pulley drive, and the size of the pulley is proportioned to give a suitable tapping speed for the work that is to be done. There are six faces on the turret, each of which is equipped with a suitable work-holding fixture, and the machine is provided with five tapping spindles. This leaves one blank position, which is shown at the front of the machine, for the purpose of removing the finished product and replacing a fresh blank. The taps work progressively to tap the holes to the required depth.

The turret is indexed by hand, the long lever at the top of the machine being provided for this purpose. When it is required to index the turret, this lever is moved to the right, which withdraws the locking bolt and allows the turret to drop onto a ball bearing track over which it is suspended. The same lever is then moved in the opposite direction to advance the work to the next station, and when this has been accomplished the locking bolt springs up to secure the turret against further rotation in either direction. A slight additional movement of the indexing lever results in lifting the turret off the roller bearing track so that its upper face comes into contact with the finished face of an aligning block, which locates the work ready for the next operation. The five spindles on the machine carry pinions which mesh with a common central gear through which they are all driven. This central gear is carried by a stem, at the lower end of which there are a pair of bevel pinions that mesh with the teeth on opposite sides of a bevel gear carried by the driving shaft. A clutch is located between the two bevel pinions so that either pinion may be engaged to secure the forward or reverse motions for the tapping spindles.

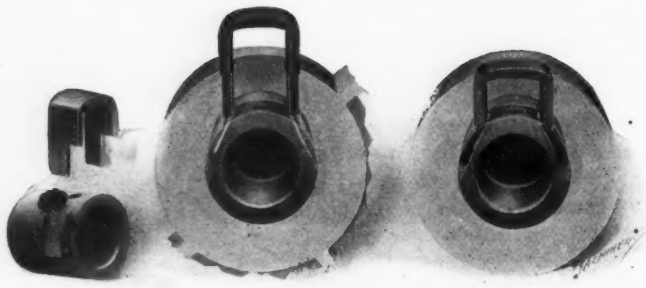
The rate at which the taps are fed to or withdrawn from the work is governed by independent lead-screws of the proper pitch, and it will be seen from the illustration that individual oil-tubes are provided to deliver cutting lubricant to the taps. The operation of the reversing clutch is automatic, and the starting or stopping of the machine is governed by the left-hand lever located just below the table. The right-hand lever provides for stopping all motions on the machine. Although this machine was particularly designed to meet the requirements of tapping rifle receivers and bolts, it will be evident that a machine of this type could be used to advantage in machining various other products. For this purpose it would simply be necessary to provide suitable work-holding fixtures.

"SIMPLEX" HARDENED STEEL BEARING LINERS AND KEYS

Templeton, Kenly & Co., Ltd., 1020 South Central Ave., Chicago, Ill., are now manufacturing a line of hardened steel bearing liners and keys which are adapted for use on practically all classes of high- and low-speed machinery. The important features of these bearing liners are the ease with which they may be applied and the positive locking device which precludes the possibility of rotary or lateral movement. The bushings are formed from a solid steel bar to produce a shell of accurate dimensions and finish. It will be seen that two keyways are milled on the outside of the shell, the keyways forming an acute angle with the diameter. The two keyways occupy similar positions relative to the diameter. The bushings are heat-treated and hardened to assure obtaining the maximum durability.

The key which holds the bearing liner in place is stamped from plate steel and formed to shape. The head of this key

Station Type of Tapping Machine built by the Baush Machine Tool Co.

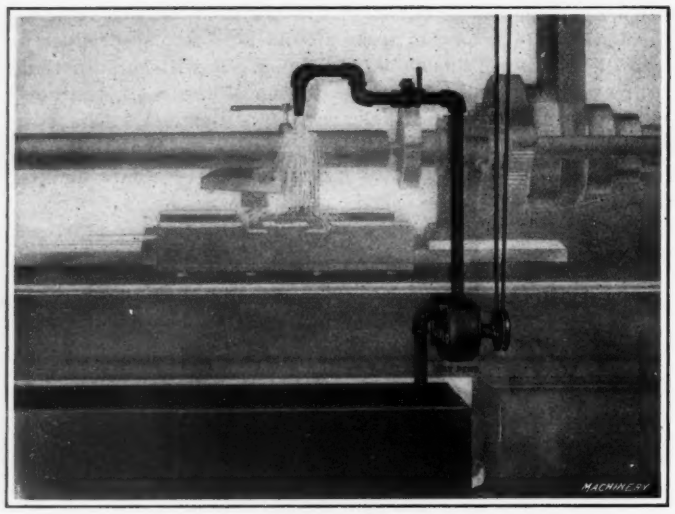


Bushing and Key, Method of assembling, and Assembled Bearing

fits snugly into the opening in the boss which carries the bearing and the two small lugs fit into the milled slots in the liner, which have been previously referred to. In this way the liner is held securely in place. In assembling this bearing the method of procedure is as follows: The shaft is placed in position and the bearing liner is slipped over the shaft and brought into place in the boss. The key is then inserted so that the ends of the lugs rest in the slots in the bearing liner, after which the key is driven home. The lugs follow the angles of the slots and expand to provide a driving fit between the frame of the machine and the outside of the bearing liner. It will, of course, be obvious that an opening is cut in the frame of the machine to receive the key.

CINCINNATI LUBRICANT PUMP

In designing the "Fulflo" lubricant pump which is illustrated and described herewith, the Cincinnati Lubricant



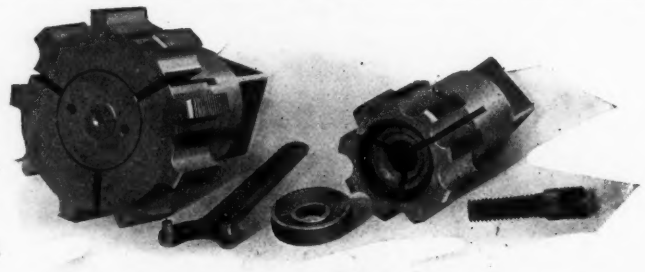
Application of Cincinnati Lubricant Pump on an Engine Lathe

Pump Co., Cincinnati, Ohio, has paid particular attention to the requirements of a pump for use on machine tools. This pump is of the centrifugal type and does not require priming, so that it is always ready to deliver a copious flow of lubricant to the tools as soon as the machine starts working. A feature of the pump is that it will pass any chips or grit which enter the intake pipe without danger of clogging or damaging the pump, and on this account it is unnecessary to use a fine strainer. The pump is mounted in a vertical position and can be placed anywhere on the machine. It will supply a volume up to 20 gallons per minute, which is sufficient to keep the tools and work cool under the most severe operating conditions.

"SOVEREIGN" ADJUSTABLE SHELL TAPS

The industry which has developed in this country in the manufacture of shrapnel and high-explosive shells for the belligerent European powers has developed some unusual conditions as regards the requirements of tools for performing the tapping operations. The tapping operations to be performed on shells are in the nose of the shell to receive the fuse and the fixing screw, and in the base of the shell to receive the gas check plug.

To meet the requirements of this work, Wood, Vallance & Co., Hamilton, Ontario, Canada, are now manufacturing a line of "Sovereign" adjustable taps, and the accompanying table



"Sovereign" Adjustable Shell Tap made by Wood, Vallance & Co.

gives the sizes in which these taps are made, together with the specific operations for which each type of tap is adapted.

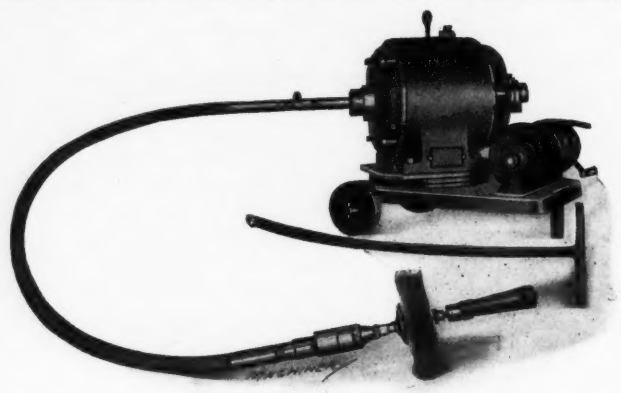
SIZE AND TYPE OF THREAD ON "SOVEREIGN" SHELL TAPS

Size of Tap		Type of Thread	Tapping Operation performed in:
Diameter	Threads per inch		
2	14	Whitworth right hand	Nose of 18 Pr. high explosive shells Socket of 18 Pr. shrapnel
2¼	14	Whitworth left hand	Socket of 4.5 high explosive shells
2.492	14	Whitworth right hand	Base of 18 Pr. high explosive shells Nose of 18 Pr. shrapnel
2.497	14	Whitworth right hand	Nose of 18 Pr. shrapnel
2.5	14	Whitworth right hand	Nose of 4.5 high explosive shells
2½	14	Whitworth right hand	Nose of 60 Pr. high explosive shells
3.375	14	Whitworth left hand	Base of 4.5 high explosive shells
3½	14	Whitworth left hand	Base of 60 Pr. high explosive shells
0.250	20	Whitworth	Fixing screw hole in all shells

Machinery

STOW PORTABLE GRINDER

In some shops it is found more convenient to take a grinding machine to the work than to attempt to follow the usual practice of taking the work to the machine, and to meet the requirements of manufacturers who have parts of this kind to grind, the Stow Mfg. Co., Binghamton, N. Y., has developed the portable grinding machine which is illustrated and described herewith. This machine is also adapted for using a



Stow Portable Grinding Machine equipped with a Wire Scratch Brush

buffing wheel or scratch brush, and is shown with a scratch brush set up ready for use. It will be seen that this outfit consists of an electric motor which drives the grinding wheel through a flexible connection, and the entire unit is mounted on a truck so that it may easily be moved from one position to another.

The motor is completely enclosed, and the starting equip-

ment is incorporated in the motor frame to provide a compact construction. Motors are provided for use on either direct or alternating current. In the direct-current equipment, variation of speed is secured by means of a plunger in the pole piece which operates to change the reluctance of the magnetic circuit. Speed variation provided in this way allows for using up emery wheels down to the minimum workable diameter and still maintaining a high cutting efficiency. The motor is designed to stand sudden overloads and is so balanced on the truck that it may be adjusted to the proper angle for all purposes.

KEUFFEL & ESSER LETTERING TEMPLETS

It is quite generally admitted that the quality of workmanship in lettering engineering drawings is below the average standard of work produced in the drafting-room. Many

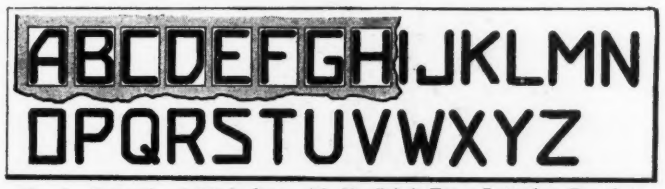


Fig. 1. Example of Work done with Keuffel & Esser Lettering Templets. Part of the Templet is shown in the Upper Left-hand Corner

draftsmen realize their shortcomings in this respect and endeavor to correct the deficiency by taking particular care in lettering drawings, with the result that too much time is spent on this work. For the purpose of improving the quality of the lettering on drawings, and also to reduce the time and expense required for the performance of this work, the Keuffel & Esser Co., Hoboken, N. J., has developed a line of lettering templets which are made for various styles and sizes of letters. In addition to their application in drafting-rooms, these templets may be used to advantage in lettering signs, show cards, price tickets, and any other form of announcement on which neat lettering is required. The templets are made for different sizes of letters varying from ⅛ to ¾ inch in height.

The templets consist of a strip of transparent xylonite with two rows of different sized holes uniformly spaced. When ink or liquid color is used for lettering, the templet is placed on a cardboard guide which raises it away from the surface of the drawing and prevents blotting. When a pencil is used, the templet is placed directly upon the drawing with its lower edge resting against the T-square, the use of the cardboard guide being unnecessary. The pen is guided along the edges of the templet holes, and lines that do not conform to the templet edges, such as the oblique lines of K, R, A, etc., may be drawn free-hand without disturbing the position of the templet. In such cases the start of the letters is made at the corners in order to establish the end points correctly; or if very careful lettering is required the end points of such letters can be marked as illustrated in Fig. 2, and subsequently joined by using a straightedge.

The first hole at the left-hand end of each templet is somewhat wider than each of the others, and is intended for draw-

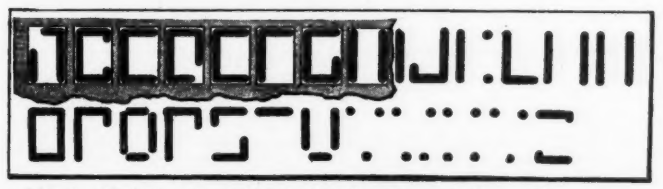


Fig. 2. Method of Procedure in locating Diagonal Lines which are to be ruled in with a Triangle

ing such letters as M and W. To draw the vertical lines of the letters T and Y, and to insure correct spacing of the letter I, the templet is shifted the distance of the spacing bar to the right or left. The end points of the oblique lines in such letters as K, R, V, W, X and Y should be marked before the templet is moved in order to use the triangle or straightedge later on, or these lines may be immediately drawn free-hand. The horizontal center lines of letters A, E, F, G, and H are also filled in free-hand as the work proceeds, or later on with the assistance of the straightedge.

Two styles of pens can be used for lettering in connection with these templets, *i.e.*, the Keuffel & Esser glass pens or the Payzant pens. The glass pens are especially adapted for this work; both ends of the pen can be used, the larger end being intended for making the heavy lines and the smaller end for the light lines of the letters. The pen should be held in a vertical position and guided along the edge of the templet perforations like a pencil. The Payzant pen, although especially developed for use in free-hand lettering, is also well adapted for application in connection with the lettering templets.

BERGER STEEL LOCKERS

The campaigns in welfare work which have been conducted in leading manufacturing plants throughout the country have led to the installation of individual lockers for workmen to keep their street clothes in during working hours. Considerations of fire risk have made it advisable to install metal lockers for this purpose, and the accompanying illustrations show steel equipments of this kind made by the Berger Mfg. Co., Canton, Ohio. Fig. 1 shows what is known as the type No. 1011 locker with three lockers arranged in a unit, and Fig. 2 shows the type No. 1016 locker in two tiers with six

Fig. 1. Berger Type No. 1011 Steel Locker

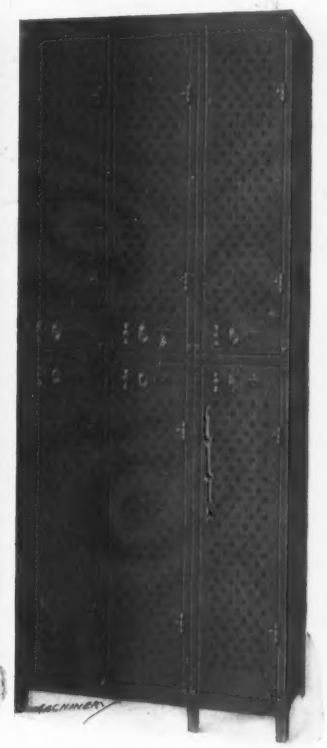


Fig. 2. Berger Type No. 1016 Steel Locker

lockers arranged in a unit. These lockers are also made in double- and single-tier types, respectively, and are typical of the line of steel lockers manufactured by this company. The single-tier lockers are made in two standard heights of 60 and 72 inches, and in various sizes ranging from 12 by 12 up to 24 by 24 inches. The double-tier lockers are made in two standard heights of 36 and 42 inches, and in sizes ranging from 12 by 12 up to 18 by 18 inches.

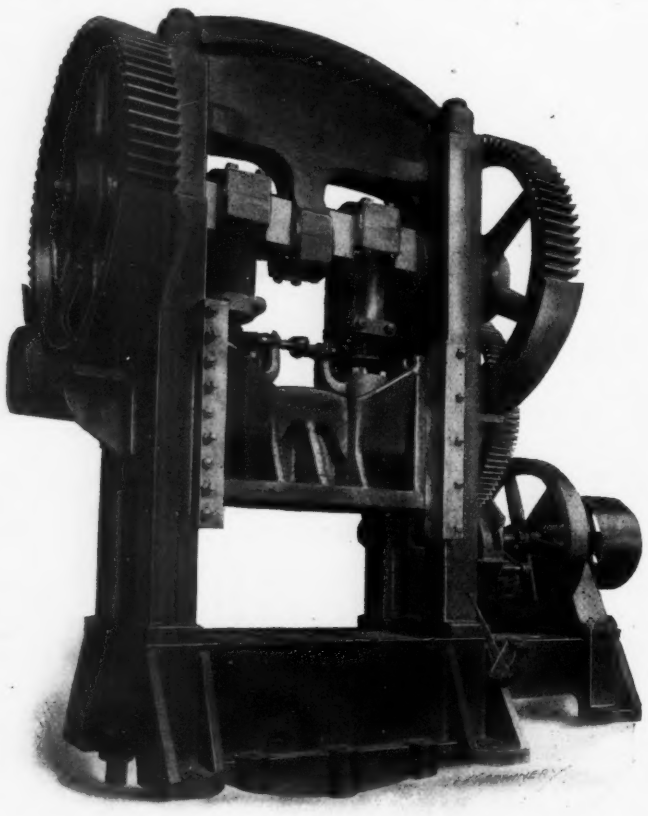
CLEVELAND HIGH-DUTY FORMING, BLANKING AND DRAWING PRESS

The high rates of production which are maintained in automobile factories have created a demand for stronger and heavier power presses for use in the making of the various parts. The machine which forms the subject of this descrip-

tion has recently been developed by the Cleveland Machine & Mfg. Co., 4944 Hamilton Ave., Cleveland, Ohio, for use in the manufacture of automobile frame cross-bars and for the performance of other heavy forming, blanking and drawing operations.

To enable it to stand up under the most severe conditions, the machine is designed with a large factor of safety so that danger of breakage is practically non-existent. A heavy spring drawing attachment (not shown) is mounted on the bed of the press and is used for operating knock-out pads and drawing or pressure rings. All of the gears on the machine are cut from steel, and the friction clutch is of the multiple disk type.

The principal dimensions of this machine are as follows: Size of bed, 48 by 72 inches; diameter of crankshaft in bearings, 10 inches; diameter of crankshaft on crank-pins, 11¼ inches; stroke of slide, 10 inches; maximum distance from



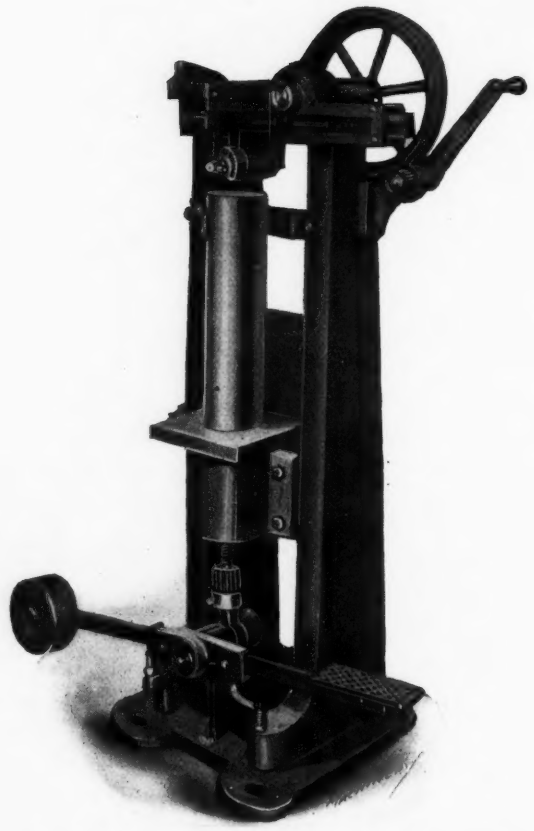
Cleveland High-duty Forming, Blanking and Drawing Press

bed to slide with the stroke down and adjustment up, 26 inches; ratio of gearing, 45 to 1; and gross weight of machine, 167,000 pounds.

NOBLE & WESTBROOK SHELL MARKING MACHINE

The machine which forms the subject of this description and which is shown in the accompanying illustration has been developed by the Noble & Westbrook Mfg. Co., Hartford, Conn., for use in marking the base of shrapnel and high-explosive shells up to 6 inches in diameter. The machines are made in two sizes known as Nos. 3-A and 3-B and have capacities for shells up to 12 inches in length and from 12 to 21½ inches in length, respectively. The design is similar to that of the Dwight Slate marking machines which have been manufactured by the Noble & Westbrook Mfg. Co. for a number of years.

In operation, the roll die passes over the base of the shell, and depressing the foot-lever raises the table to the proper position for any depth of marking. The No. 3-A machine is arranged with a hand-lever, and by one pull of this lever the die revolves and completes the marking operation. On the No. 3-B machine, a geared drive is provided in order to get the required pressure for marking large shells without requiring undue effort on the part of the operator. Using these machines, shells can be marked on the base practically as



Noble & Westbrook Machine for marking End of Shrapnel and High-explosive Shells

fast as they can be lifted to and from the machine, as the operation of marking only requires from five to ten seconds, according to the size of the shell.

NEW MACHINERY AND TOOLS NOTES

Shell Cutting-off Machines: Automatic Machine Co., Bridgeport, Conn. Machines adapted for use in cutting off the ends of shell forgings. These machines are built in two sizes, which have capacities for all shells up to 6 and 9 inches in diameter, respectively.

Boring and Turning Mill: H. Bickford & Co., Lakeport, N. H. A boring mill equipped with power rapid traverse for the tool spindles as well as for the saddles. The machine is of simple construction and easily operated. Machines of this type are built in 4, 5, 6 and 7 foot sizes.

Hydraulic Banding Press: Southwark Foundry & Machine Co., Philadelphia, Pa. A six-cylinder hydraulic machine for pressing the copper bands onto shrapnel and high-explosive shells. The machine is equipped with the usual form of hardened steel dies for compressing the band.

Boring and Tapping Tool: Murchey Machine & Tool Co., Detroit, Mich. A tool intended for machining automobile differential housings, but which is applicable for other classes of work. The tool is intended for the performance of boring and tapping operations and the work is clamped around it.

Heavy-duty Lathe and Turret Lathe: Oliver Machinery Co., Grand Rapids, Mich. A 16-inch quick-change lathe and a turret lathe. These machines are designed with ample power, and are rigidly constructed to enable them to stand up under the severe strains incident to operation in factories engaged in the manufacture of shells.

Portable Electric Grinders: Standard Electric Tool Co., Cincinnati, Ohio. Two portable grinders, one of which is the so-called "aerial" type, in which the entire tool is suspended from overhead, while the other is a double wheel grinder of the pedestal type. These tools can be used for buffing operations as well as for grinding.

Combination Disk Wheel and Sander: Oliver Machinery Co., Grand Rapids, Mich. A machine intended for use in pattern shops, which is equipped with one spindle that carries a disk wheel and another spindle for a sander. These machines are built with 24- and 30-inch disk wheels, and with 2-, 3-, and 4-inch sanding drums.

Post Drilling Machine: Luther Grinder Mfg. Co., Milwaukee, Wis. A machine adapted for use on small, light or special work in pattern, repair and machine shops. The feed is easily regulated to suit the work which is being drilled. The tool is strongly made and adapted for hard service; it may be set up on any post or column in the shop.

Electric Soldering Machine: Detroit Electric Welder Co., Detroit, Mich. A machine for the performance of soldering operations, which works on the same principle as an electric welding machine, although the temperature obtained is not so high. The machine has a table to which a suitable holding fixture may be fastened for carrying the work.

Semi-automatic Turning Machines: Amalgamated Machinery Corporation, Chicago, Ill. A line of semi-automatic machines which includes turning, boring, drilling and inside finishing machines. These are designed for straight and form turning, boring, drilling, reaming, tapping, facing, and other operations on shrapnel and high-explosive shells.

Duplex Drilling Machine: Wilcor Mfg. Co., 4824 W. Lake St., Chicago, Ill. A machine in which the headstocks are mounted on the bed to provide a swing of 10 inches, and on which the headstocks are horizontally adjustable to provide the maximum gap of 30 inches. The spindles have a traverse in the heads of 3½ inches and are bored for Morse taper shank drills.

Shrapnel Box Machines: Greenlee Brothers & Co., Rockford, Ill. These machines are particularly adapted for use in boring the spacing boards used in boxes for holding shrapnel and high-explosive shells. Two machines are built for this purpose, which are of the multiple-spindle type, so that all of the holes in a spacing board may be drilled at one time.

Cutting Machine for Sheet Metal: W. J. Savage Co., Knoxville, Tenn. A machine provided with a vertically reciprocating tool, which is similar in its action to a slotting machine. The sheet metal to be cut is automatically fed to the tool by a pair of rollers. Straight or irregular shapes are readily cut at a speed of 20 to 42 inches per minute, and the capacity of the machine is for metal up to 3/16 inch in thickness.

Radial Drill: Almond Mfg. Co., Cleveland, Ohio. This machine is of similar design to the radial drill equipped with a tapping attachment which has been manufactured by this company for some time. It is built in two styles, one of which is mounted on a base while the other is intended for clamping to a column. Three changes of speed are provided, ranging from 390 to 1000 revolutions per minute. The drilling radius is 4 feet.

Electroplating Barrel: U. S. Electro-galvanizing Co., Brooklyn, N. Y. An automatic machine for the performance of electroplating operations. It consists of an automatic plating barrel for treating nails, screws and similar parts in bulk. The plating barrel is used in connection with automatic cleaning and drying outfits, so that electroplating is completed without requiring the work to be handled after it has been loaded into the machine.

Cylinder Grinding Machine: Boxill & Bruel Machinery Co., Cincinnati, Ohio. This machine is an improved design of the same type of grinder formerly manufactured by this company. On the improved machine, the frame is so designed that the grinding wheel may be withdrawn and swung to one side while calipering the work. The wheel head is pivoted to its base so that when the wheel is run up clear of the cylinder it may be swung to one side.

Upright Drill: Richards Machine Co., Milwaukee, Wis. The design of this machine follows established practice in the construction of this type of machine tool, but the parts subject to severe service have been made unusually heavy. The spindle is provided with the usual lever and ratchet movement, and a small pilot wheel at the opposite end of the pinion spindle assists in setting the drill spindle or running it up and down. The weight of the machine is 250 pounds.

Horizontal Drilling Machine: Moline Tool Co., Moline, Ill. This machine was designed for automobile work, but is applicable in various other classes of manufacture, where multiple drilling is to be done. The machine has two 20-inch rails on which any of the drill heads made by the Moline Tool Co. may be mounted. The spindles in these heads are driven through a worm which extends almost the entire length of the rail, so that the setting of individual heads is an easy matter.

Shell Under-cutting and Waving Machine: Thurlow Steel Works, Chester, Pa. A machine designed for finishing the band seat on shells. The work is held in a hardened and ground steel collet which is controlled by means of a lever at the side of the headstock. The machine is provided with four forming tools—two at the back and two at the front. The tools at the back cut the right- and left-hand sides of the under-cut, while the tools at the front rough out the band seat and perform the waving operation.

Manufacturing Lathe: Fairbanks-Morse & Co., New York City. This machine has been especially designed to meet the requirements of manufacturers of shrapnel and high-explosive shells. The drive is provided by a single pulley which carries an 8-inch belt. The machine is driven by a two-speed countershaft, and when so driven six changes of speed are available. The principal dimensions are: swing over bed, 26½ inches; swing over carriage, 14½ inches; distance between centers, 60 inches; ratio of double back-gears, 11 to 1 and 8 to 1.

* * *

QUOTATIONS OF WHOLESALE METAL PRICES

Week Ending November 26

Aluminum, pig, per pound, ton lots	$ 0.60
Antimony, Asiatic, per pound	0.39½
Black sheets, No. 28, per 100 pounds, Pittsburg	2.40
Copper, electrolytic, per pound	0.19¾
Copper, lake, per pound, New York	0.19¾
Galvanized sheets, No. 28, per 100 pounds, Pittsburg	4.25
Iron bars, refined, per 100 pounds, Pittsburg	1.86
Iron, pig, foundry No. 2, per ton, Philadelphia	17.75
Iron, pig, basic, valley, furnace, per ton	16.00
Iron, pig, Bessemer, per ton, Pittsburg	17.95
Iron, pig, gray forge, per ton, Pittsburg	16.45
Lead, per pound, New York	0.05¼
Nails, cut, per 100 pounds, Pittsburg	1.85
Nails, steel wire, per 100 pounds, Pittsburg	1.90
Spelter, per pound, New York	0.19
Steel angles, per 100 pounds, Pittsburg	1.70
Steel bars, per 100 pounds, Pittsburg	1.70
Steel beams, per 100 pounds, Pittsburg	1.60
Steel billets, forging, per ton, Pittsburg	50.00
Steel rails, per pound, at mill	0.01¼
Steel tank plates, per 100 pounds, Pittsburg	1.90
Tin, per pound, New York	0.39½
Tin plate, per 100-pound box, New York	3.54
Wire, barbed, galvanized, per 100 pounds, Pittsburg	2.75

The demand for metals continues unabated and prices are steadily advancing. Pig iron has gone up fifty cents a ton. The United States Steel Corporation, finding the demand for its products so great, has temporarily withdrawn quotations in foreign markets. The rumored merger of steel plants has not yet been confirmed. Charles M. Schwab, president of the Bethlehem Steel Co., denied that the Bethlehem Steel Co. and the Cambria Steel Co. were about to consolidate. He referred in the interview to a prediction made in 1900 that by 1920 the annual production of the United States would increase from 10,000,000 tons, the figure at which it then stood, to 40,000,000 tons in 1920. The production is now at the rate of about 37,000,000 tons annually and the prospects are that the prediction of 40,000,000 tons annual production will be realized before the time set. The quotations in the foregoing list are to a large degree nominal, fancy prices in many cases being paid for steel and other metals on quick delivery.

* * *

MONTHLY MEETING OF THE A. S. M. E.

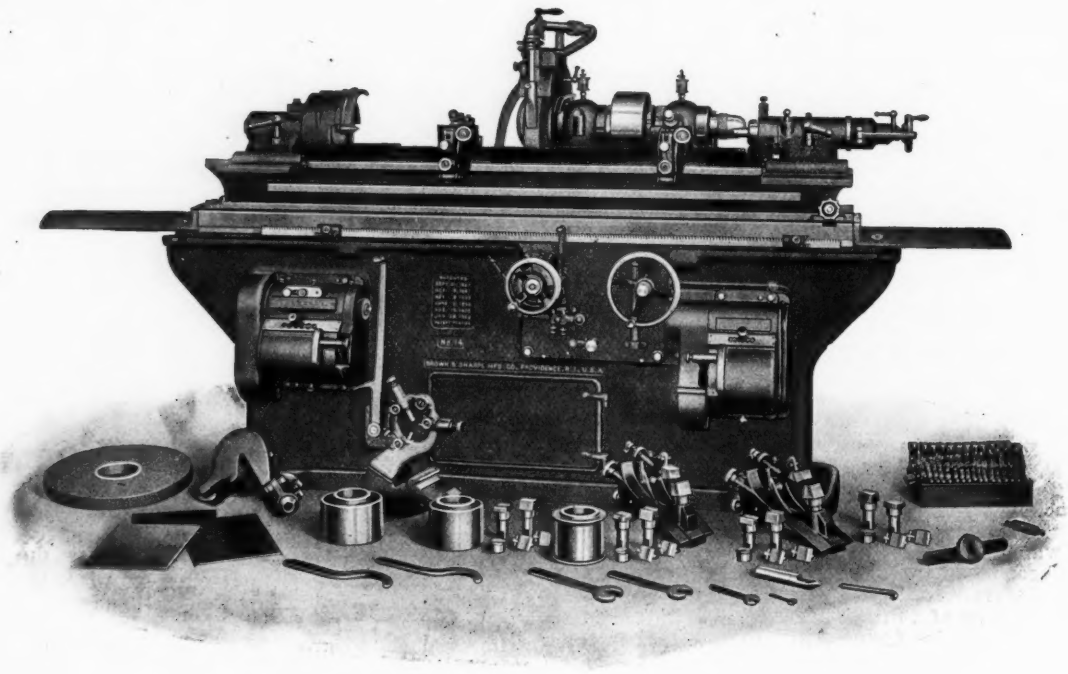
The monthly meeting of the American Society of Mechanical Engineers was held Tuesday evening, November 9, in the Engineering Societies Bldg., New York City. Charles Meids Ripley delivered an address on individual power plants *vs.* the central station power plant for power purposes in New York City. Mr. Ripley has made an extended investigation of the size, age and performance of all the gas producer power plants in the city, that is, plants that are self-contained power producing units, using coal and converting its energy into electrical energy for power purposes, thereby obviating the necessity of purchasing electricity from a distributing company. The results of Mr. Ripley's investigations indicate that the individual power plant is to be preferred in city office buildings because the power costs the owner practically nothing in winter when the building must be heated. Exhaust steam is practically as effective for heating a building as steam used direct from the boilers. The reduction of pressure due to the passage of the steam through a steam engine means loss of heat of only about four per cent, this being the heat energy converted into electrical energy.

* * *

The National Machine Tool Builders Association, which held its annual meeting at the Hotel Astor, New York City, October 28-29, elected J. B. Doan, president, D. M. Wright, first vice-president, A. H. Teuchter, second vice-president, C. S. Taylor, secretary, A. E. Newton, treasurer. Cincinnati, Ohio, was chosen as the place for the spring convention in May.

* * *

MACHINERY has been advised that a young Englishman, familiar apparently with the machine tool trade in Great Britain and America, now in this country, is trying to borrow money from machine tool builders and dealers on the strength of his alleged trade connections. Charles Churchill & Co., Ltd., of London, whom he offers as reference, cabled that the man is an impostor.



After the High Explosives—What?

High explosives are the center of interest in this issue; what they are and what they do—how they are made—methods and machines for manufacture, and so forth.

Almost every producer of shells knows how well our plain grinding machines are adapted to his work. So consider these machines from another standpoint:

When the feverish rush of war production is over—after high explosives cease to be an active manufacturing interest—in what condition will your equipment be? After months of almost uninterrupted operation, working night and day, and being driven to the limit, will it still be able to produce profitable results on your regular work?

This war activity is a severe test for machines from the standpoints of production and construction. Handy and efficient design enables B. & S. Grinding Machines to meet the first demand by an ample margin. But it is the typical B. & S. sturdiness and honesty in construction, the careful attention to even the smallest details in manufacture, that enable these machines to stand the pace under such severe conditions.

These machines are not merely short lived investments—they are good for long service. The qualities that insure good production now, mean the same efficient results later. These features are typical throughout the line, a good representative of which is shown above in a

Brown & Sharpe No. 14 Plain Grinding Machine

Brown & Sharpe Mfg. Co.,

OFFICES: 20 Vesey St., New York, N. Y.; 654 The Bourse, Philadelphia, Pa.; 626-630 Washington Blvd., Chicago, Ill.; 305 Chamber of Commerce Bldg., Rochester, N. Y.; Room 419, University Block, Syracuse, N. Y.

REPRESENTATIVES: Baird Machinery Co., Pittsburgh, Pa., Erie, Pa.; Carey Machinery & Supply Co., Baltimore, Md.; E. A. Kinsey Co., Cincinnati, O., Indianapolis, Ind.; Pacific Tool & Supply Co., San Francisco, Cal.; Strong, Carlisle & Hammond Co., Cleveland, O., Detroit, Mich.; Colcord-Wright Machinery & Supply Co., St. Louis, Mo.; Perine Machinery Co., Seattle, Wash.; Portland Machinery Co., Portland, Ore.

Some Reasons Why

these machines represent a profitable investment for quality, production, accuracy and long service are to be found in the features described below. They are good points to consider when you are buying grinding equipment.

Independent Gear-Driven Speed and Feed Change Mechanisms

insure that all-important requirement in commercial grinding—complete separation of speeds and feeds. Through two simple, efficient, and handily located mechanisms, an operator can quickly secure the most productive combination of speed and feed for each job. No overhead belts to shift, no confusion—a quick start and maximum production every time.

Automatic Cross Feed

Here's a feature that not only saves time and trouble but also insures exact duplication of work. It is quickly and easily set and once set succeeding pieces are reduced to the predetermined size without attention from the operator, who can prepare work or run another machine while a piece is being ground.

Combination Plain and Universal Back Rests

Another handy B. & S. feature. Work requires proper support. That is essential. These rests can be used in three ways—as universal back rests with delicate adjustments for long slender work; semi-universal for work of medium weight, and solid rests to give rigid support to heavy pieces.

Low Setting, Rigid Headstock

The solid, compact design of the headstock meets that important requirement in a machine for heavy grinding—rigidity. The work centers are located directly above solid walls of metal extending to the floor and giving very solid support.

Wheel Spindle Speeds

can be readily varied to suit the requirements of various classes of work, by means of split pulleys which can be quickly changed. An automatic belt tightener maintains an even belt tension and compensates for differences due to changing pulleys and to the different positions of the wheel slide.

General Design Makes for Handy Operation

That's why operators like these machines. Every operating part is arranged for handy access and to eliminate confusion and waste motion. Convenience like that is a big factor in fast production. Write for descriptive literature and learn more about these efficient machines. Also ask for our booklet "Points About Grinding Machines and Their Selection."

Providence, R. I., U. S. A.

CANADIAN AGENTS: The Canadian-Fairbanks-Morse Co., Ltd., Montreal, Toronto, Winnipeg, Calgary, Vancouver, St. Johns, Saskatoon.

FOREIGN AGENTS: Buck & Hickman, Ltd., London, Birmingham, Manchester, Sheffield, Glasgow. F. G. Kretschmer & Co., Frankfort a.M., Germany; V. Lowener, Copenhagen, Denmark, Stockholm, Sweden, Christiania, Norway; Schuchardt & Schutte, Petrograd, Russia; Fenwick, Freres & Co., Paris, France; Liege, Belgium; Turin, Italy; Zurich, Switzerland; Barcelona, Spain; The F. W. Horne Co., Tokio, Japan; L. A. Vail, Melbourne, Australia; F. L. Strong, Manila, P. I.

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REPORTED MERGER OF MACHINERY PLANTS

Wide publicity has been given in the newspapers to a report that the plants of the National-Acme Mfg. Co., Cleveland, Ohio, and Montreal, Canada; Windsor Machine Co., Windsor, Vt.; American Steam Gage & Valve Mfg. Co., Boston, Mass.; R. B. Phillips Mfg. Co. of Worcester and Lowell, Mass.; and White Mountain Paper Co., Portsmouth, N. H., have been merged into a $25,000,000 corporation named the Phillips Corporation, a holding concern formed under the laws of Delaware, and that Ralph B. Phillips, treasurer and general manager of the American Steam Gage & Valve Mfg. Co., the moving spirit in the merger, is president, and Lloyd H. Atkinson, formerly of the Bethlehem Steel Co., is vice-president. The report includes a statement that Mr. Phillips and his associates have obtained contracts for the manufacture of war munitions aggregating about $60,000,000, and assurance is given that the constituent companies, which employ a total of about 7500 people, will continue to operate with few immediate changes in the present organization. The subsidiary concerns in the corporation are to make shells, fuses, munition parts, heavy ordnance machine tools and engage in shipbuilding. According to the report one-half of the stock issue of $25,000,000 is to be seven per cent cumulative preferred, and the balance common. At the time of going to press the principals would not confirm the foregoing.

* * *

STATEMENT OF THE OWNERSHIP, MANAGEMENT, ETC.

of MACHINERY, published monthly on the 1st, at New York, N. Y., for October 1, 1915, required by the Act of August 24, 1912.

Editor, Fred E. Rogers	140-148 Lafayette St., New York				
Managing Editor, None					
Business Managers	Alexander Luchars, President	"	"	"	"
	Matthew J. O'Neill, Gen'l Manager	"	"	"	"
Publisher, The Industrial Press		"	"	"	"
Owners of one per cent or more of the stock:—					
The Industrial Press		"	"	"	"
Alexander Luchars		"	"	"	"
Matthew J. O'Neill		"	"	"	"
Fred E. Rogers		"	"	"	"
Louis Pelletier		"	"	"	"
Erik Oberg		"	"	"	"

There are no bondholders, mortgagees or other security holders.

MATTHEW J. O'NEILL, General Manager.

Sworn to and subscribed before me this 1st day of October, 1915

FRANK J. SCOTT,
Notary Public No. 321, Kings County,
Certificate filed in New York County No. 247.
(SEAL) (My commission expires March 30, 1917.)

PERSONALS

J. D. Sherman, formerly efficiency engineer of the Illinois Tool Works, Chicago, has been appointed superintendent of the plant.

Paul B. Goddard, general manager of the Illinois Tool Works, Chicago, Ill., has resigned his position and connection with the company.

Forrest E. Cardullo, a well-known mechanical engineer and contributor to the technical press, has taken a position with the Pierce-Arrow Motor Car Co., Buffalo, N. Y.

E. Lagerholm, until recently traveling representative of the Illinois Tool Works, Chicago, has been made sales manager. Mr. Lagerholm was previously with the Union Twist Drill Co. as manager of that company's Chicago branch.

Halbert P. Hill, well known in engineering circles as an inventor and designer in the early development of the rotary converter and allied apparatus for the conversion of alternating current into direct current, is now connected with the C & C Electric & Mfg. Co. of Garwood, N. J.

* * *

OBITUARIES

Daniel O. Rogers, for many years vice-president of the Skinner Chuck Co., New Britain, Conn., died November 12 at his home in New Britain, aged sixty-one years.

Abraham Van Brunt Bush, formerly master mechanic and chief draftsman for the Waterbury Rope Co., died October 24, at his home, 265 Seventh Ave., Brooklyn, N. Y., in his eighty-seventh year.

William Barker, one of the pioneer machine tool builders in the Middle West, died November 9, aged sixty-three years. He was president of William Barker & Co., lathe builders, Covington, Ky.

Baxter D. Whitney of Baxter D. Whitney & Son, the oldest manufacturer of wood-working machinery in America, died at his home in Winchendon, Mass., October 17, aged ninety-eight years. His father was a woolen manufacturer and he learned the trade of machinist at a very early age and went into business for himself before he was twenty years old. The first machines he made were used in the manufacture of woolen cloth, but soon he turned his attention to the improvement of machinery for working lumber. He began to study the cylindrical planer problem and finally built a successful machine that was sold to a local concern. Cylindrical planers had been built before Mr. Whitney made his, but in none of them was it possible to plane a board without clipping the ends. Among the most notable of Mr. Whitney's contributions to the art of wood-working, besides the cylindrical planer, is the gage lathe and the wood-scraping machine.

COMING EVENTS

December 6-8.—International trade conference, arranged by the Foreign Trade Department of the National Association of Manufacturers, at the Hotel Astor, New York City. William M. Benney, 30 Church St., manager, Foreign Trade Department, National Association of Manufacturers.

December 7-10.—Annual meeting of the American Society of Mechanical Engineers, New York City; Engineering Societies Bldg., headquarters. Calvin W. Rice, secretary, 29 W. 39th St., New York City.

September 11-16, 1916.—Convention of the American Foundrymen's Association and the American Institute of Metals, Cleveland, Ohio, in the Cleveland Coliseum. A. O. Backert, secretary-treasurer, American Foundrymen's Association, Cleveland Ohio.

NEW CATALOGUES AND CIRCULARS

Mesta Machine Co., Pittsburg, Pa. Circular of Mesta barometric condensers for steam power plants.

Allsteelquip Co., Aurora, Ill. Leaflet 101 advertising "Allsteelquip" steel lockers, general service cabinets, office shelving and transfer cases.

Adams Co., 715 Market St., Dubuque, Iowa. Catalogue 69 of the Farwell No. 0 quick-change milling machine, keyseater, profiler and cam cutter.

Richard W. Jefferis Co., Camden, N. J. Folder Y, covering dimensions and prices of Jefferis pressed-steel storage equipment and office wardrobes.

Standard Electric Tool Co., Cincinnati, Ohio. Bulletin G 9, superseding Bulletin G 8, of "Standard" high-power ball bearing portable electric grinders.

Gardner Governor Co., Quincy, Ill. Circular on air compressor installations, giving helpful hints to those concerned with the installation and maintenance of air compressors.

Pangborn Corporation, Hagerstown, Md. Bulletin 531 of the Type L A direct high-pressure rotary table sandblasting machine built in two sizes, with tables of 70 and 90 inches diameter, respectively.

Sidney Tool Co., Sidney, Ohio. Circular of the Sidney high-duty seventeen-inch and nineteen-inch double back-geared quick-change engine lathes built in six-, eight-, ten- and twelve-foot lengths of beds.

Vulcan Engineering Sales Co., 2063 Elston Ave., Chicago, Ill. Catalogue 3 of Hanna pneumatic riveters, screen shakers, revolving dumping riddles, suction oilers, cold metal sawing machines, jib cranes, etc.

Whiting Foundry Equipment Co., Harvey, Ill. Catalogue 14 treating of Whiting brass foundry equipment which includes furnaces, blast pipes, gratings, tongs, structural work for pits, tumblers, and cranes.

Charles H. Besly & Co., 120-B N. Clinton St., Chicago, Ill. Bulletin 17 of the Besly wide-face ring wheel grinder, illustrated with examples of work done and details of the pressed steel chuck and geared motion lever feed.

Roller-Smith Co., 203 Broadway, New York City. Pamphlet on "Junior-Imps," which is the trade-name used to designate Roller-Smith small direct-current ammeters and voltmeters for battery charging outfits, small switchboards, and similar applications.

United Engine & Mfg. Co., Hanover, Pa. Bulletin 22 of the "Manley" "long range" arbor press, having a leverage of 100 to 1 and a capacity of ten tons. The maximum capacity between standards is twenty-one inches and under the ram forty inches.

Jenckes Knitting Machine Co., Pawtucket, R. I. Circular describing the Chernack multiple lathe for rough-turning. This machine turns five pieces about ten inches in length and from three to six inches diameter simultaneously and can be adjusted to turn fewer pieces of greater length.

Bantam Anti-Friction Co., Bantam, Conn. Pamphlet called "Shopology," a statement of general authority and relations of employes, that is placed in the hands of each employe and all new men when put to work. This booklet concludes with some efficiency axioms of general application in all manufacturing plants.

Huther Bros. Saw Mfg. Co., 1108 University Ave., Rochester, N. Y. Pamphlet descriptive of the Huther inserted-tooth milling saw, which comprises two crucible steel plates between which are riveted high-speed steel teeth. The saw is designed for thin and fast cutting, and it is claimed that it will withstand severe strain and shock.

Clarence E. Van Auken Co., 216 N. Clinton St., Chicago, Ill. Circular of the Van Auken hacksaw, illustrating and describing a hacksaw machine with two opposed blades working on opposite sides of the stock simultaneously. The claim is made that the machine will saw four times as fast as the single saw dry machine.

Hammacher, Schlemmer & Co., 4th Ave. and 13th St., New York City. Circular of "Metalite" cloth furnished in rolls of fifty yards each. This form of abrasive cloth is economical for shop use, as it eliminates considerable waste. The rolls are supplied in widths from ¼ inch to 2½ inches and in grits Nos. 3/0 to 3½.

Foxboro Co., Foxboro, Mass. Bulletin 98 on Foxboro recording gages for continuously recording on a paper chart the amount and duration of fluctuation in vacuum or pressure. The booklet illustrates these gages and some of the charts made by them, and gives price lists of recording pressure gages and recording vacuum gages.

Porter-Cable Machine Co., Syracuse, N. Y. Circular of the Porter-Cable manufacturing lathe, especially designed for the economical production of duplicate parts in large quantities. The lengths of bed are 32 and 38 inches, having capacity between centers of 12 and 18 inches, respectively. The swing is 9 inches over the bed.

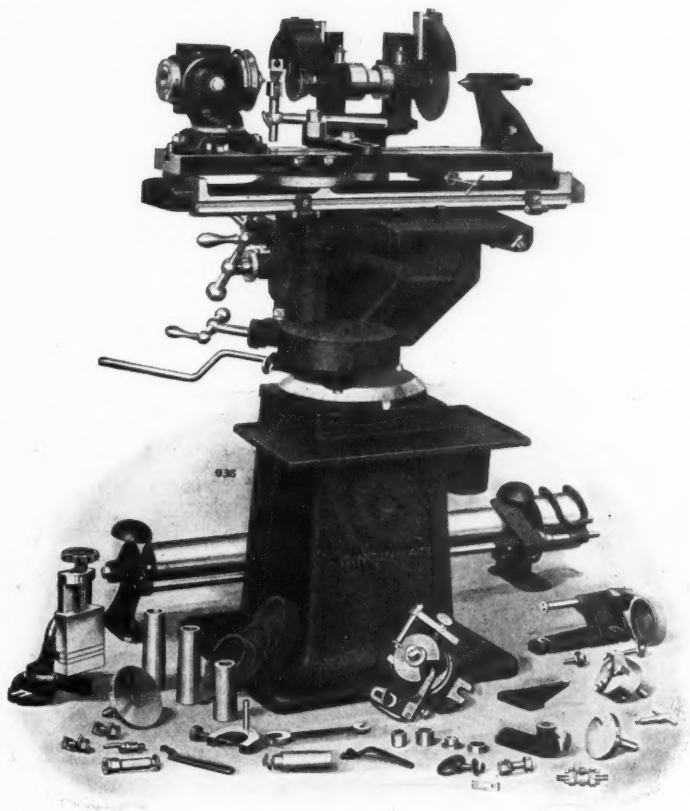
New Departure Mfg. Co., Bristol, Conn. Bulletin 51 FE, "Ball Bearing Mounting for Large Blower;" 52 FE, "Ball Bearing Installation in Ammonia Compressor for Refrigerating Work;" 53 FE, "Methods of Retaining Lubricant in Bearing Housings where Stream Lubricant is Necessary;" 54 FE, "Mounting Ball Bearings in Self-aligning Housings."

Sprague Electric Works of General Electric Co., 527-531 W. 34th St., New York City. Bulletins 49126 and 49127 on ozonators for use in cold storage warehouses, and ozonators for use in stores, respectively. This equipment is used for deodorizing the air in storage rooms where food is kept or in other places where the air becomes rapidly contaminated.

Keuffel & Esser Co., 127 Fulton St., New York City. Pamphlet of "Simplex" lettering templets for lettering and numbering drawings without any preliminary layout. The work can be done uniformly and rapidly by a person who has had no previous experience in lettering by means of these templets. Either ink or pencil can be used, special glass pens being made for working with ink.

Southwark Foundry & Machine Co., 430 Washington Ave., Philadelphia, Pa. Circular of the McMeans-Bosler cutting-off machine for cutting rounds from one to thirteen inches diameter into shell blanks. The machine consists of a powerful

CLEARANCE



The No. 1½ Cincinnati Universal Cutter and Tool Grinder

Patent Rights Fully Reserved

You wouldn't think of using lathe tools with the wrong clearance. On milling cutters correct clearance is even more important.

Incorrect cutter clearance will reduce the output of your milling machines as much as twenty per cent.

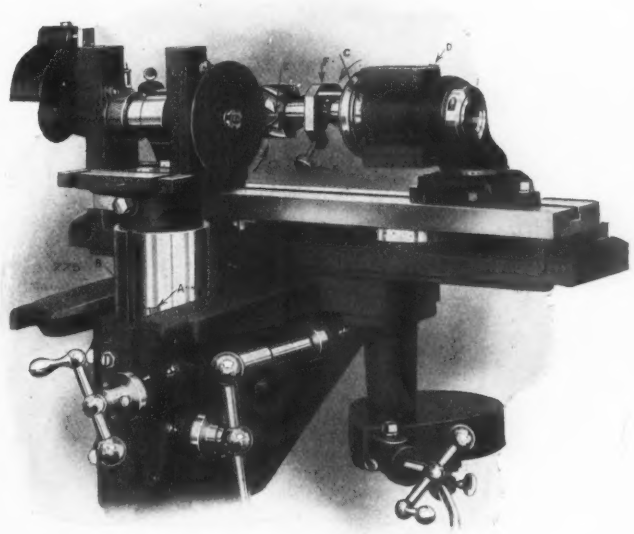
Clearance depends upon certain mathematical relations between the cutter and the grinding wheel.

To obtain these on the ordinary grinder requires several measurements and reference to diagrams, tables or charts.

The average operator doesn't understand these and after a couple of trials grinds until the clearance looks right—and your milling department suffers.

Compare the Cincinnati method. After a simple preliminary setting the swivel head is revolved the desired amount, the clearance angle being read direct from the dial—the cutters are ground with the correct clearance—and your milling department profits.

This is only one of our *exclusive features.*



Method of setting for clearance.

Catalogue tells them all.

Cincinnati Milling Machine Company

CINCINNATI **OHIO, U. S. A.**

headstock driven by electric motor and six sets of cutters worked by air cylinders. The rate of production is claimed to be six cuts on 5½-inch rounds in sixty-five seconds.

Harrison Safety Boiler Works, Seventeenth St. and Allegheny Ave., Philadelphia, Pa. Booklet entitled, "Firing and Stopping of Waste in Modern Boiler Rooms." The value of feed-water and condensate meters as aids in the management of power plants is pointed out. With a feed-water meter installed it is possible to measure the effect of changes in boiler room management and thus to fix on the most economical practice.

Industrial Controller Co., 850-890 Greenbush St., Milwaukee, Wis. Handbook No. 4 of I. C. controlling devices, comprising D. C. motor starters; D. C. speed regulators; A. C. motor starters; A. C. speed regulators; D. C. automatic starters; D. C. starting speed regulators; accessories; battery charging rheostats and resistance units; and field rheostats. Walker Bros. & Haviland of New York, Philadelphia and Chicago, are the general sales agents.

American Metal Products Co., 3009-3021 Lisbon Ave., Milwaukee, Wis. Circulars of "Ampco" bronzes which, in sand castings, have a range of tensile strength from 50,000 to 100,000 pounds per square inch and an elastic limit of 25,000 to 45,000 pounds per square inch. When forged, hammered, rolled or drawn, the tensile strength is as high as 150,000 pounds per square inch. Die-casting "Ampco" bronze is successfully cast in iron or steel molds without causing rapid deterioration of the molds.

Westinghouse Electric & Mfg. Co., East Pittsburg, Pa. Leaflets 2389 and 2390 dealing with belt-driven and engine-driven alternating-current generators, respectively, with capacities ranging from 25 to 1750 kilovolt amperes; leaflet 3787 on type CS, large squirrel-cage induction motors, designed for heavy-duty, constant-speed continuous service; and leaflet 3811 on installations of electric drive in steel mills, with curve indicating the growth of this form of power in steel mills throughout the country.

Ingersoll-Rand Co., 11 Broadway, New York City, has issued two booklets, Forms 76 and 9201. Form 76 is an 80-page catalogue entitled "Water Lifted by Compressed Air," and describes in detail the air lift system of pumping. Form 9201 is a 128-page catalogue on "Calyx Core Drills." The principal function of the core drill is the determination of the character, order, thickness and extent of the strata beneath the earth's surface by means of cylindrical cores extracted by the drill. In coal and metal mines, stone quarries, contract work, canal or tunnel developments projected, etc., the core drill is used to prospect the unknown formation and give the engineers absolute knowledge of the formation that must be excavated.

American Express Co., 65 Broadway, New York City. Booklet entitled "Foreign Trade Building," dealing with the establishment of trade abroad. The company has had more than a quarter of a century of actual business experience in the foreign field, and the benefit of its experience is offered to American manufacturers in the hope that they will fully appreciate the importance of starting right. The foreign trade information bureau will furnish general information on any country regarding language, currency and exchange conditions, weights and measures, steamship lines and routes, postal regulations, distribution of imports and exports, competition, trade conditions, catalogue requirements, invoice regulations, insurance, collections, patent and trade-mark laws, etc.

TRADE NOTES

Hyatt Roller Bearing Co., Newark, N. J., has appointed J. D. Mooney manager of its commercial department. Mr. Mooney was formerly in charge of the belting sales for the B. F. Goodrich Co., Akron, Ohio.

Fafnir Bearing Co., New Britain, Conn., recently opened a new branch office at 39 S. Clinton St., Chicago, Ill., with D. D. Davis as manager. This office was established to take care of the increased business developing in the western territory.

C. & C. Electric & Mfg. Co., Garwood, N. J., will exclusively manufacture the horizontal and vertical ball bearing motor generator sets for moving picture machines and battery charging outfits, designed and patented by Halbert P. Hill.

Van Dorn & Dutton Co., Cleveland, Ohio, specialist in gears and gear cutting, has moved its New York office from 50 Church St. to 556 W. 34th St. Frank Van Anden has been appointed district sales manager in charge of the New York office.

Standard Mfg. Co., Bridgeport, Conn., has made plans to increase the working floor space of its plant approximately 13,000 square feet. The increase has been found necessary to properly take care of the large volume of work on hand and of the probable future business.

American Vanadium Co., 325 Vanadium Bldg., Pittsburg, Pa., has developed a carbon-vanadium forging steel which is claimed to give all the physical requirements of heat-treated, quenched and tempered plain carbon steel forgings of like section, without heat-treatment other than simple annealing.

Phoenix Mfg. Co., Eau Claire, Wis., builder of machine tools, has opened an eastern office at 1480 W. Sixth St., Cleveland, Ohio, in charge of W. L. Harrison. For the past two years the company has made a specialty of turret attachments, such as four-tool turret toolposts and four- and six-hole carriage turrets.

U. S. Electrical Mfg. Co., 459-461 E. Third St., Los Angeles, Cal., manufacturer of direct- and alternating-current machinery will immediately rebuild its factory, destroyed by fire October 27. The company requests catalogues of machine tools and other equipment used in the manufacture of electrical motors.

Sprague Electric Works of General Electric Co., 527-531 W. 34th St., New York City, has recently opened a sales office in the Provident Bank Bldg., Cincinnati, Ohio, under the management of Frank H. Hill. The Cincinnati office has been established to facilitate the prompt and efficient handling of the increasing business in that section.

Kelly Reamer Co., Cleveland, Ohio, manufacturer of the Kelly type reamers, has recently brought out a special type of reamer for shell and shrapnel work, and the orders have accumulated so rapidly that plans are made for doubling the capacity of the plant. The company now occupies the entire floor of the building in which it is located.

W. P. Davis Machine Co., 305 St. Paul St., Rochester, N. Y., has been purchased by J. M. Fitzgerald and associates and the name has been changed to the Davis Machine Tool Co., Inc. The capacity of the plant will be considerably enlarged. F. H. Brown, who has been with the company for years as secretary and treasurer, will be retained as assistant to the president. The capitalization is $750,000.

Cleveland Galvanizing Works Co., Cleveland, Ohio, has acquired an entire city block adjacent to its works at E. Cooper Ave. and Pennsylvania R. R. The additional property will permit the company, which manufactures a line of weldless wire chain, sash chain, and chain of all kinds, to greatly enlarge its plant. The demands for its product are now much greater than the capacity of the present plant.

Hess-Bright Mfg. Co., Front St. and Erie Ave., Philadelphia, Pa., whose rights under the Conrad patents on ball bearings were sustained by broad decisions rendered by the United States courts, has licensed the Standard Roller Bearing Co., Philadelphia, Pa., the New Departure Mfg. Co., Bristol, Conn., Gurney Ball Bearing Co., Jamestown, N. Y., and the U. S. Ball Bearing Co., Chicago, to manufacture ball bearings under the Conrad patents.

Springfield Grinding Co., Springfield, Mass., manufacturer of abrasive wheels, has been incorporated with an authorized capital of $400,000. The company will operate the abrasive plant in Chester, Mass., formerly operated by the Massassoit Co. This plant was sold last August at a foreclosure sale to Dwight O. Gilmore of Springfield, who will act as president of the new company. A. D. Robinson of Westfield, Mass., is vice-president and C. J. Wetsel treasurer. The factory manager is A. F. Blouin.

National Tool Co., Cleveland, Ohio, manufacturer of milling cutters, reamers, taps and other small tools, has recently made important additions to its plant which will considerably increase the shop capacity. The new building for heat-treatment is constructed along original lines worked out by Ed. Noll, president and general manager. Mr. Noll has spent many years in the manufacture of small tools, and during the past ten years has built up an independent business under the name of National Tool Co. A new office building will be erected at an early date.

F. H. Kappen & Son, Milwaukee, Wis., have opened an office at 93 W. Water St., for the sale of wood- and iron-working machinery and other specialties. They have taken over the merchandise and machinery of the O. L. Packard Machinery Co. and in addition will act as manufacturers' agents. F. H. Kappen was connected with the O. L. Packard Machinery Co. as salesman and manager up to 1891, when the Kappen corporation was formed of which he became secretary and treasurer. Ralph A. Kappen, the junior member, has been active in the same business in various capacities for about five years.

Billings & Spencer Co., Hartford, Conn., has reorganized under the general law of Connecticut and increased its capitalization from $200,000 to $500,000. The limitations of the company's old charter made necessary the organization of a new corporation in order to increase its capital. The Billings & Spencer Co., which has taken over the entire assets and business of the old corporation, has assumed its liabilities. The officers are: C. E. Billings, president and general manager; F. C. Billings, vice-president and superintendent; Lewis D. Parker, treasurer; E. H. Stocker, secretary; and F. H. Stocker, assistant secretary and treasurer.

Simonds Mfg. Co., Fitchburg, Mass., has signed contracts with the United States Steel Corporation for license and with the American Bridge Co. for the installation of a five to six gross ton Heroult three-phase electric melting furnace. The results obtained by the company with electric furnaces during the past five years have indicated to its engineers that a larger furnace of the type now building would be desirable. It is expected that the complete installation will be one of the best yet made in this country for the manufacture of high-grade carbon and alloy steels. The new furnace will be put into operation about January 1, 1916.

Walker M. Levett Co., 10th Ave. and 36th St., New York City, maker of "Magnalite" pistons for gas engines, furnished the pistons for all the American cars entered in the 350-mile Astor cup race that was run October 9. Of the eight cars that finished "in the money," only one had pistons of another make, these being machined from solid steel billets. In the foreign cars that were compelled to drop out of the race because they were unable to withstand the terrific strains imposed in the 102-mile an hour pace, broken connecting-rods proved the biggest factor, thus emphasizing the importance of eliminating as much weight as possible in reciprocating parts.

Hoover Steel Ball Co., Ann Arbor, Mich., has increased its capital stock from $250,000 to $500,000, the addition of capital being required for further expansion of the company's business. In the past twelve months, the company has erected three new buildings, affording 30,000 square feet additional floor space, and has installed ball-making machinery worth $160,000. But these additions to the productive capacity were not sufficient to provide for the increased demand for steel balls. Last January the company brought out a new ball known as the "Micro-chrome" steel ball. Within six months, orders had been booked for approximately $800,000 worth of these new balls, which had met with general approval.

R. E. Parsons Co., Bridgeport, Conn., which for the past forty-three years has been in operation at the corner of Barnum Ave. and Hallet St., will now be controlled by other parties interested very closely in the product of the concern. The business was started in a small way by R. E. Parsons, who until recently was the controlling stockholder, but who on account of advancing years wished to be relieved of his responsibility in the concern. His holdings were bought by Clarence E. Bilton, president of the Standard Mfg. Co., and Frederick Rhodes, treasurer of the Salt's Textile Mfg. Co. These gentlemen, together with John W. Cottrell, the president of the R. E. Parsons Co., will conduct the business as heretofore under the same name.

S. K. F. Ball Bearing Co., 50 Church St., New York City, announces that Frank A. Vanderlip of the National City Bank has been elected director of the S. K. F. Ball Bearing Co. of Hartford. The company was recently incorporated under the laws of Connecticut for the purpose of taking over the business of the S. K. F. Ball Bearing Co. of New York, a house importing ball bearings made in Sweden. The new company has acquired the right to manufacture S. K. F. ball bearings in America from the Swedish company and is about to erect a factory for this purpose at Hartford, Conn. It has a fully paid up capital of $2,000,000. The board of directors will consist of B. M. W. Hanson, Franklin B. Kirkbride, A. Carlander, S. Winquist, B. G. Prytz and Frank A. Vanderlip.

Federal Machinery Sales Co., 12 N. Jefferson St., Chicago, Ill., has completed its organization and leased the building which was formerly occupied by the Niles-Bement-Pond Co. and the Pratt & Whitney Co. The company is incorporated with an authorized capitalization of $50,000. The officers are: James L. Gough, president; J. B. Doan, vice-president; Charles T. Bush, treasurer; and James Jay Sheridan, secretary. Mr. Gough has had long experience in the machine tool business from his connection with several prominent houses. Mr. Doan and Mr. Bush need no introduction to the trade, having been associated as vice-president and general manager of the American Tool Works Co., Cincinnati, and the Charles A. Strelinger Co. of Detroit, respectively. Mr. Sheridan is a prominent Chicago attorney. The new organization will handle a complete line of new and used machine tools and allied lines.

Nicholson File Co., Providence, R. I., has been made a member of the Rice Leaders of the World Association. The company was incorporated in Rhode Island in 1864 to manufacture files and rasps. Its main plant and offices are in Providence and other factories are maintained at Paterson, N. J., Anderson, Ind., and Port Hope, Ontario, Canada. William Thomas Nicholson, founder of the company, while operating a small machine shop of his own, built his first file-cutting machine. The superior merits of Nicholson files soon became known and the business grew rapidly. The company manufactures at its Providence plant alone more than 3500 kinds of standard files. The officers are: Samuel M. Nicholson, president and general manager; Walter W. Griffith, secretary; Paul C. Nicholson, vice-president; Henry W. Harman, assistant treasurer; Harold C. Field, assistant secretary; Ernest S. Craig, assistant to the president; and Wallace L. Pond, manager sales department.

Hyatt Roller Bearing Co., Newark, N. J., announces that the increase in its business has so far exceeded expectations that the construction of three buildings, instead of one, as planned, has become imperative. A. P. Sloan, general manager of the company, states that business everywhere is going forward and his company must not be behindhand in preparing for it. The three new buildings will increase the facilities by one-third. When they are complete, the company will have a total of over 600,000 square feet floor space devoted exclusively to the manufacture of roller bearings, which will make it by far the largest plant of its kind in the world. Two of the new buildings will be twin structures, each 200 feet long, 50 feet wide, and eight stories high. The third building will be 90 feet wide, 110 feet long and six stories high. The twin buildings will be used for press work, assembly of roller bearing parts and shipping. The other structure is especially designed for the heat-treating processes so important in bearing manufacture. The heat-treating building will be provided with an elaborate ventilation system which will insure that the men may work at all times in comfort. A central duct, which increases in size from the first floor to the top, changes all the air on each floor every minute. The system is operated by four fans, each ten feet in diameter, located in a housing on the roof. The gases will be taken out through separate ducts that lead directly to the main flue. By this system, the employes will suffer no inconvenience from combustion gases or excessive heat. The heat-treating building is being constructed of reinforced concrete and brick veneer, while the twin buildings are to be of concrete, steel and brick.